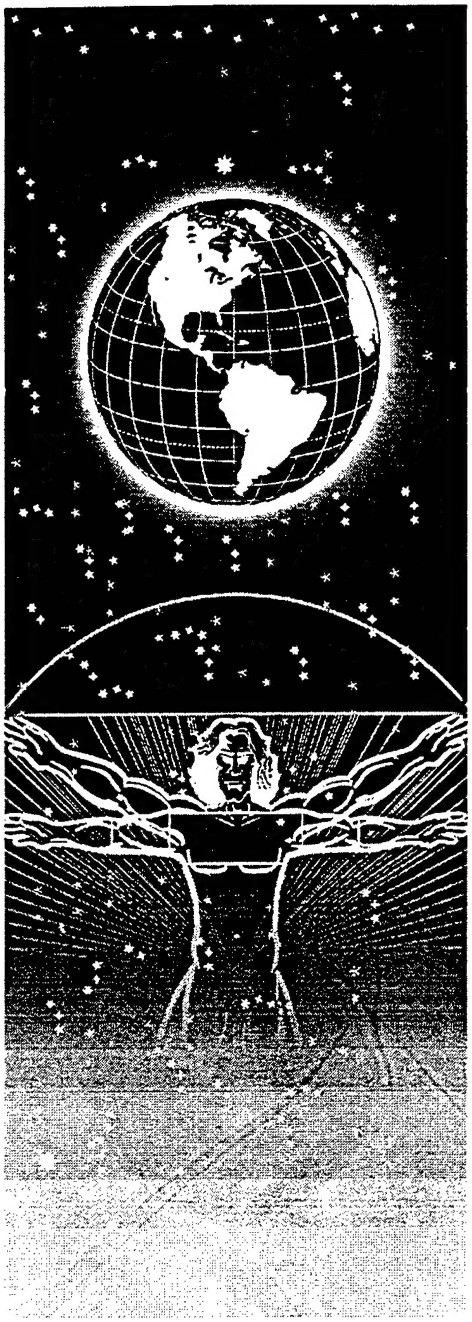
AL/OE-TR-1997-0142



UNITED STATES AIR FORCE
ARMSTRONG LABORATORY

Federal Interagency Committee on Aviation Noise: Report on Aviation Noise Research Conducted By U.S. Federal Agencies

Robert L. Miller
Mary Ellen Eagan

Harris, Miller, Miller & Hanson
15 New England Executive Park
Burlington MA 01803

DTIC QUALITY INSPECTED 2

December 1997

19980113 231

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Occupational and Environmental Health Directorate
Bioenvironmental Engineering Division
Noise Effects Branch
2610 Seventh Street
Wright-Patterson AFB OH 45433-7901

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TECHNICAL REVIEW AND APPROVAL

AL/OE-TR-1997-0142

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

Robert A. Lee

ROBERT A. LEE
Chief, Noise Effects Branch

FOR THE DIRECTOR

LARRY T. KIMM, Major, USAF, BSC
Chief, Bioenvironmental Engineering Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
December 1997

3. REPORT TYPE AND DATES COVERED
Interium June 1993 thru June 1994

4. TITLE AND SUBTITLE

Federal Interagency Committee on Aviation Noise: Report on Aviation Noise Research Conducted by U. S. Federal Agencies

5. FUNDING NUMBERS

C - F33615-89-C-0574
PE - 633037F
PR - 3037
TA - 303701
WU - 3037015A

6. AUTHOR(S)

Robert L. Miller and Mary Ellen Eagan

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Harris, Miller, Miller , and Hanson
15 New England Executive Park
Burlington MA 01803

8. PERFORMING ORGANIZATION

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Armstrong Laboratory, Occupational and Environmental Health Directorate
Bioenvironmental Engineering Division
Noise Effects Branch
2610 Seventh Street
Wright-Patterson AFB OH 45433-7901

10. SPONSORING/MONITORING

AL/OE-TR-1997-0142

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

A

13. ABSTRACT *(Maximum 200 words)*
The Federal Interagency Committee on Aviation Noise (FICAN) was formed in 1993 to provide forums for debate over needs for future aviation noise research and to encourage new development efforts in this are. All Federal agencies concerned with aviation noise are represented on the Committee, including the Department of Defense, the Department of the Interior, the Department of Transportation, the Environmental Protection Agency, the National Aeronautics and Space Administration, and the Department of Housing and Urban Development.
This report introduces current and planned research topics in aviation noise. The work summarized here represents the individual (or sometimes joint) initiatives of member agencies. Fifty-nine projects on aviation noise were identified by FICAN members. Areas of study include: investigation of new criteria for determining land use compatibility, examination of community reactions to aircraft noise, perception of aircraft noise and how it is affected by background noise, acoustic issues associated with rotary wing aircraft, noise effects on animals, development and improvement of computer models, noise reduction technologies, improved public information materials, and structural damage effects.

14. SUBJECT TERMS
Noise Aviation
Federal Interagency Committee on Aviation Noise (FICAN)

15. NUMBER OF PAGES
110

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89) Prescribed by ANSI Std Z-39-18
298-102 COMPUTER GENERATED

U.S. Department of Defense
U.S. Army Environmental Hygiene Agency
Bioacoustics Division
Attn: HSHB-M-B
Aberdeen Proving Ground
Aberdeen, MD 21010-5422

U.S. Department of the Interior
National Park Service
P.O. Box 37127
Washington, DC 20013

U.S. Department of Transportation
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, DC 20591

U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

U.S. National Air and Space Administration
NASA Langley Research Center
Hampton, VA 23681

U.S. Department of Housing and Urban Development
451 7th Street, S.W.
Washington, DC 20410

Table of Contents

List of Exhibits

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EXECUTIVE SUMMARY

Introduction

The Federal Interagency Committee on Aviation Noise (FICAN) was formed in 1993 to provide forums for debate over needs for future aviation noise research and to encourage new development efforts in this area. All Federal agencies concerned with aviation noise are represented on the Committee, including the U.S. Army (USA), the U.S. Air Force (USAF), the Department of Interior (DOI), the Department of Transportation (DOT), the Federal Aviation Administration (FAA), the U.S. Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), and the Department of Housing and Urban Development (HUD). Of these, the Air Force, the Army, the FAA, and NASA are sponsoring the large majority of current research.

To help coordinate these and future Federal initiatives, FICAN expects to meet semi-annually and will hold several additional forums to obtain broader input from the public at large as well as from interested members of the technical community.

The Committee's tasks for Fiscal Year 1994 include:

- holding semi-annual FICAN meetings to discuss the status of research projects conducted by Federal agencies concerned with aviation noise,
- conducting a public forum to obtain input from interested parties on future research needs,
- soliciting input from members of the technical and aviation communities at conferences and other appropriate venues, and
- preparing a report summarizing the status of aviation noise research projects funded through Federal agencies.

Since its inception, FICAN has met twice, the first in November, 1993, and the second on 28 and 29 March 1994. Its first public forum is being coordinated to coincide with the annual meeting of the National Organization to Improve a Sound Environment (N.O.I.S.E.) scheduled for later this summer in Atlanta, Georgia on 28 July 1994. Plans to interact with the technical and aviation communities are still being formulated. This report addresses the fourth of its tasks.

General Conclusions

Fifty-nine projects on aviation noise were identified by FICAN members[1]. Areas of study include: investigation of new criteria for determining land use compatibility, examination of community reactions to aircraft noise, perception of aircraft noise and how it is affected by

1 Additional projects of a significantly more technical nature also are underway at several agencies. They have not been included in this report.

background noise, acoustic issues associated with rotary wing aircraft, noise effects on animals, development and improvement of computer models, noise reduction technologies, improved public information, and structural damage effects.

Among these topics, the greatest focus is on community reactions to aircraft noise, noise reduction technologies, noise effects on animals, and new or improved computer models. For example, to better understand community reaction, the U.S. Army is conducting several investigations on annoyance, the Air Force and NASA are conducting research on sleep interference, and the Air Force is examining the feasibility of a prospective epidemiologic study of the effects of aircraft noise exposure on human health.

To improve noise reduction technologies, NASA has commenced an Advanced Subsonic Technology Initiative, a primary objective of which is to achieve a 10 dB reduction in aircraft noise exposure by the year 2000 compared to 1992 baseline levels. Air Force research in advanced technology is directed toward applications of active sound cancellation techniques to engine test cells, flight demonstration projects, and earplug design.

Regarding the effects of noise on animals, the Air force and the Army are exploring noise effects on domestic, grazing, and wild animals, as well as on poultry and birds of prey; of special interest are the effects of overflights in Military Operating Areas (MOA's) and along Military Training Routes (MTR's).

Finally, a number of FICAN member agencies are developing new noise models and improving existing models for predicting both long-term and short-term exposure, as well as exposure from unconventional operations, such as Military Training Routes and sonic booms. These and other topics are discussed in more detail in the sections which follow.

1. INTRODUCTION

The Federal Interagency Committee on Aviation Noise (FICAN) was formed in 1993 to provide forums for debate over future research needs to better understand, predict, and control the effects of aviation noise, and to encourage new development efforts in these areas.

As a starting point, this report serves to introduce current and planned research topics in aviation noise to the public at large. The work summarized here represents the individual (or sometimes joint) initiatives of member agencies, but it is important to recognize that the Committee, itself, does not fund this research. The projects are the efforts of different Federal agencies, all of whom have had long-standing interests and concerns regarding aircraft noise. FICAN will serve to help coordinate future work within these agencies. Section 1 of the report describes the formation of FICAN and its mandate; Section 2 presents an overview of each agency's responsibility for aircraft noise as well as a summary of the overall research effort being carried out by those members sponsoring such work; Section 3 catalogues the specific projects underway or planned for the near future, grouped by topic area; and Section 4 is a list of references. Appendix A presents more detailed descriptions of each project funded by the member agencies; Appendix B provides a glossary of terms and an explanation of abbreviations.

1.1 Background

In 1992, the Federal Interagency Committee on Noise (FICON) published its findings in a report entitled "Federal Agency Review of Selected Airport Noise Analysis Issues" (FICON, August 1992). Among its findings, the Committee identified a need to increase research on the basic elements of aircraft noise assessment methods including (1) a reexamination of Day-Night Average Sound Level (or DNL) as the primary metric for describing aircraft noise, (2) an evaluation of the dose-response relationship between DNL and its effect on people (quantified as percent of people highly annoyed), and (3) the appropriateness of the noise criteria used to define compatibility with different land uses.

To foster the research, FICON recommended that a new Federal interagency committee be formed with a mandate to provide forums for debate of future research needs and to encourage new development efforts in these areas. FICON also provided initial guidance on research topics of concern to its members. They included:

- Development of new land use compatibility guidelines to improve their usefulness for land use planning;
- Further investigation of community reaction to aircraft noise, including additional research on sleep disturbance, non-auditory health effects, and speech interference, ultimately leading to the development of improved criteria for assessment of impacts;

- Identification of differences in peoples' perceptions of aircraft noise and traffic noise, and how those perceptions are influenced by background noise; and

- Extension of noise assessment methods to the unique noise signatures of rotary-wing aircraft.

1.2 Development of FICAN

The committee tasked with advancing and coordinating future research and development efforts in these and other areas is known as the Federal Interagency Committee on Aviation Noise. All Federal agencies concerned with the effects of aviation-related noise are represented on the Committee, including the Army (USA), Air Force (USAF), Department of Interior (DOI), Department of Transportation (DOT), Federal Aviation Administration (FAA), Environmental Protection Agency (EPA), National Aeronautics and Space Administration (NASA), and Department of Housing and Urban Development (HUD). The Committee expects to meet semi-annually and will hold additional forums to obtain broader input from the public at large and the technical community.

FICAN does not conduct or directly fund any research. Individual Federal agencies control the direction and funding of their own research programs. FICAN serves as a forum for members to discuss research findings, identify topics requiring research, and solicit the public's concerns about aviation noise effects. It is expected that FICAN efforts will lead to expanded coordinated and cooperative research efforts among individual agencies and, thus, result in more efficient use of Federal funds.

Participating member agencies have signed a Letter of Understanding, which defines the purpose, scope, membership, process, and products of FICAN, and formally documents the commitment of the participating agencies. This Letter of Understanding is reproduced in Appendix A.

The Committee's agenda for Fiscal Year 1994 includes:

- holding semi-annual FICAN meetings to discuss status of research projects conducted throughout Federal agencies dealing with aviation noise,
- conducting a public forum to obtain input from interested parties on future research needs,
- soliciting input from technical and aviation community at conferences and other appropriate venues, and
- preparing a report summarizing the status of aviation noise research projected funded through Federal agencies.

This report addresses the last of these elements.

1.3 FICAN Members

Each of the Federal agencies conducting significant research on aviation-related noise is represented on FICAN. In addition, other agencies which currently are not conducting research, but have broad policy roles with respect to aviation noise issues (such as HUD and EPA), are represented on the committee. The FICAN membership list is presented in Table 1.

Table 1. FICAN Members

Member	Department/Agency Represented
Mr. Thomas L. Connor, Chair	Department of Transportation/Federal Aviation Administration
Ms. Pat Haman	Environmental Protection Agency
Dr. Wesley Henry	Department of the Interior/National Park Service
Mr. Arnold Konheim	Department of Transportation/Office of the Secretary
Major Robert Kull	Department of Defense/U.S. Air Force
Mr. Jim Littleton	Department of Transportation/Federal Aviation Administration
Dr. George Luz	Department of Defense/U.S. Army
Mr. Ken Mittleholtz	Environmental Protection Agency
Dr. Jake Plante	Department of Transportation/Federal Aviation Administration
Dr. Clemans A. Powell	National Aeronautics and Space Administration
Mr. Joel Segal	Department of Housing and Urban Development
Dr. Kevin Shepherd	National Aeronautics and Space Agency

2. FEDERAL AGENCY RESEARCH PROGRAMS

Each Federal agency undertaking significant noise research is represented on FICAN. FICAN member agencies share a common goal of addressing aviation-related noise, but each individual agency has its own mission, and agency research programs are designed to carry out that mission. The ultimate purpose and underlying mission for agency research, therefore, is critical to understanding the motivation for individual projects and the context in which that research is carried out.

The program goals and mission for each agency are discussed below.

2.1 U.S. Air Force

Noise research for the U.S. Air Force is conducted under the purview of Armstrong Laboratory. The mission of the Laboratory's environmental noise program is to maintain the Air Force's ability to conduct flight operations at its airfields, military training routes and operations areas, weapons ranges, and other controlled and restricted airspace. This is accomplished by preventing or controlling encroachment of airfields and ranges, implementing aircraft mission realignment actions and acquiring and maintaining airspace. Performance of this mission is dependent on the ability to describe and assess, in a timely and defensible manner, the magnitude and impact of subsonic and supersonic noise.

Strong public and congressional opposition to vital Air Force aircraft operations continues to grow because of possible noise and sonic boom impacts. In order to properly train pilots and maintain their abilities to engage in air combat, it is imperative to maintain sufficient airspace in various types of environments. The Air Force is also required to describe potential impacts on the environment of proposed operations. Various legislative actions are currently pending that could severely restrict flight training. In addition, farmers and ranchers, as well as other people, complain about jet aircraft noise. Sometimes individuals claim damages caused by aircraft overflights. These claims range from damage to domestic cattle and exotic birds to human health and trauma.

In order for the Air Force to better predict aircraft noise and sonic booms and the potential impact on the environment, the Armstrong Laboratory maintains the Noise Effects Branch at Wright-Patterson Air Force Base, Ohio. This organization is responsible for developing predictive noise models, measuring noise and sonic booms, and understanding the effects of noise and sonic booms on the environment. This requirement fulfills the need of the National Environmental Policy Act of 1969.

The Air Force wants to maintain a "Good Neighbor" policy and attempts to address both public and congressional concerns. Since answers to many of the questions that arise are not known, the Air Force invests in projects to understand the impacts of its flying operations and possible ways to mitigate impacts if they arise.

2.2 U.S. Army

The central question of Army noise research is to define the psychological rules by which people add up the perceptions of individual single event levels (SELs) into a single percept of "high annoyance". The first hint that these rules do not always conform to the equal energy principle come from social surveys of people exposed to aircraft, traffic and weapons noise at Forts Bragg and Lewis (Schomer, 1985) in which respondents were more annoyed by blast noise than predicted by the National Academy of Sciences (NRC, 1981). Then, studies of annoyance of individual helicopter SELs conducted inside real houses with real flyovers demonstrated that, when the SEL is accompanied by "a lot of rattle", subjects add a penalty of as much as 20 dB to the helicopter SEL (Schomer and Neathamer, 1987). This demonstration, which depended on the type of house in which the subjects were listening, was one of the reasons leading to the Army decision to conduct all psychoacoustic research in real buildings with real sounds. Another reason was the Army's legal responsibility to assess the consequences of its noise on German citizens as well as U.S. citizens. Given that the sound insulation of German residential construction is significantly greater than that of U.S. construction, the Army needed to know whether an outdoor SEL experienced in a German home was as annoying as the same SEL in a U.S. home.

The need to understand the interaction between construction and SEL led to the conversion of a small brick building at Aberdeen Proving Ground into a four room test facility (brick room, German doors, windows; brick room with U.S. doors, windows; wood frame room, German doors, windows; wood frame room, U.S. doors, windows). A parallel test house was funded by the German government in Munster, Germany. Although the primary outcome of research conducted in these facilities has been to establish that the annoyance of explosions increases at about twice the rate of the annoyance of continuous noises (Schomer, 1994), the facilities are located close to an Army airfield, which would allow for the addition of aircraft flyovers to the current real-life stimuli of rifle fire, explosions and truck drive-bys.

A major cost in conducting research in the Aberdeen Proving Ground test house is paying for subjects and paying for the real life sounds. Studying people's annoyance judgments in their own homes, although less controlled, might be less expensive. For this purpose, the Army has adapted a commercial pocket computer to be used as an interview device. Clipped to a homeowner's belt, the computer can be activated upon hearing an annoying sound. The device then leads the respondent through a series of questions about the nature and annoyance of the noise. By comparing the time of each interview with the times of SELs collected by automated noise measuring equipment outside the home, Army scientists hope to deduce the rules by which respondents come to a decision about the annoyance of a daily exposure. The device was field-tested at Fort McNair (exposed to National Airport noise) in February 1993, and an improved version was used in a study of sleep disturbance funded by the Air Force. In 1994, the device was put into use in the vicinity of Aberdeen Proving Ground.

The Army also is conducting research into mitigating the annoyance of helicopter noise. Software to predict helicopter noise propagation from weather data was tested by a group of NATO scientists at Alamogordo, NM in 1993 (White and Schomer, 1994).

2.3 U.S. Environmental Protection Agency

Section 1500.2(f) of the National Environmental Policy Act (NEPA) instructs Federal departments and agencies to "use all practicable means, consistent with the requirements of the Act and other essential considerations of national policy, to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions upon the quality of the human environment."

Section 309(a) of the Clean Air Act states, "The [Environmental Protection Agency (EPA)] Administrator shall review and comment in writing on the environmental impact of any matter relating to duties and responsibilities granted pursuant to this Act or other provisions of the authority of the Administrator, contained in any .... newly authorized Federal projects for construction and any major Federal agency action ..."

Pursuant to the NEPA and Section 309 of the Clean Air Act, EPA reviews and comments on proposed major Federal actions that significantly affect the quality of the human environment.

Additionally, the EPA is authorized to develop and submit recommendations to the Federal Aviation Administration regarding noise produced by aircraft and aircraft-related activities under the Noise Control Act of 1972 and the Quiet Communities Act of 1978.

The EPA also participated in the Federal Interagency Committee on Noise (FICON), which reviewed Federal policies governing the assessment of airport/air facility noise impacts. As a result of the FICAN recommendations, EPA is developing a guidance manual for EPA staff who provide scoping and review comments on NEPA documents. This guidance should be available during the summer of 1994.

In 1982 the EPA's Office of Noise Abatement and Control was closed for budgetary reasons. Subsequently, the EPA's involvement with noise issues has been largely limited to issues related to NEPA review and comment under Section 309 of the CAA.

Types of aircraft-related Federal actions which may require NEPA review and Section 309 comment include: construction of a new airport, new runway construction, runway extensions, proposed changes in flight corridors or relation of flight corridors, introduction of new aircraft types at an airport/air facility, a proposed increase in number of annual flight operations, proposed changes in long-term runway use, proposed change of ground operations, and proposed changes in maintenance run-up impacts.

2.4 Federal Aviation Administration

The FAA mission is to provide a safe, secure, and efficient global aviation system which contributes to national security and the promotion of U.S. aviation. As the leading authority in the international aviation community, FAA is responsive to the dynamic nature of customer needs, economic conditions and environmental concerns. In this last area, FAA must assume an advocacy role for both the environment and the industry. In addition, FAA should identify problems early and work out reasonable solutions before they become national problems.

Goal 9 of the FAA Strategic Plan (FAA, 1993) calls for the agency to provide strong leadership in mitigating the adverse impact of aviation. The first objective under that goal is to reduce the impact of aircraft noise by 80 percent (based upon population) by 2000, through an optimal mix of new aircraft noise certification standards, operational procedures, and technology. Under the mandate of the National Environmental Policy Act, the Noise Control Act, CFR 14 parts 36 and 150, FAA's research program addresses the environmental consequences of FAA's actions and identifies procedures and technologies to reduce aircraft noise.

A major activity is the FAA/NASA long-term research program to investigate the state of technology to reduce aircraft noise from airframe and engines as part of the Advanced Subsonic Aircraft Technology Initiative. The NASA section of this report provides more details on this program. FAA's role in the program is to understand the technology under consideration and to help guide the program toward solutions that are technologically practicable and economically reasonable. Along with program elements to identify manufacturing technologies to reduce noise, the community noise impact program element will assess operation noise reduction possibilities and identify methods to minimize community noise impact.

The community noise impact program has close ties to another part of the agency's research program to promote advances in the state-of-the-art technologies to assess and abate aviation environmental effects. The approach to improve and expand upon existing environmental assessment capabilities includes an integrated system of analytical tools, guidelines and training regimens to apply to the assessment of the environmental impacts of agency actions.

The return on investment is measured by the agency's actions to diminish aviation environmental impacts while also removing constraints upon aviation system growth. Better means of assessing aviation noise impacts will lead to better agency decisions on the aviation system and reduce environmental constraints on airport and system capacity.

2.5 U.S. Department of Housing and Urban Development

The Department of Housing and Urban Development maintains a liaison with other Federal agencies on research and demonstration activities related to noise and its effect upon housing and land use. The Department's concern with noise as a major source of environmental

pollution can be traced back to the objectives of the Housing Act of 1949 which established a national goal to provide "a decent home and a suitable living environment for every American family". In 1961, the Federal Housing Administration's appraisal guidance material identified noise as an issue to be considered in property appraisals in order to meet the requirements of the Housing Act of 1949. A subsequent concern about noise was voiced in the Housing and Urban Development Act of 1965 which requested HUD to "determine feasible methods of reducing the economic loss and hardships suffered by homeowners as a result of the economic depreciation in the values of their properties following the construction of airports in the vicinity of their homes." This included a study of feasible methods of insulating such homes from the noise of aircraft.

HUD's first comprehensive noise standards were issued in 1971 in HUD Circular 1390.2: Noise Abatement and Control. The Circular contained standards for exterior noise levels along with policies for approving HUD supported or assisted housing in high noise areas. This circular was canceled in 1979 with the issuance of 24 CFR 51 Subpart B "Noise Abatement and Control" which converted the existing noise policy to regulation and made improvements for a more flexible policy and made it consistent with other Federal agencies' noise programs. Revisions included: (1) bringing the policy into conformity, through the use of the Day-Night Average Sound Level, separate standards and measurements for aircraft and non-aircraft noise; (2) removing the dual exterior and interior standards, hence, if exterior noise levels are found to be acceptable, the interior noise will be considered acceptable using normal building techniques; and (3) allowing use of already existing data, particularly from the Federal Highway Administration and Department of Defense. The standards apply primarily to HUD-sponsored new construction activities and can be applied to rehabilitation activities. These standards are not binding on local communities for non-HUD assisted activities. In addition to its own regulations, the Department is tasked by Federal Management Circular 75-2, *Compatible Land Uses at Federal Airfields,* to promote compatible land uses around Federal Airfields. Lastly, HUD is a signature to the Federal Interagency Committee on Urban Noise Report *Guidelines for Considering Noise in Land Use Planning and Control,* (FICUN, 1980).

24 CFR Part 51 Subpart B "Noise Abatement and Control" established Departmental standards, requirements and guidelines for all HUD housing and community development programs. The regulation encourages the control of noise at its source in cooperation with other Federal agencies; encourages land use patterns for housing and other noise-sensitive urban needs that will provide a suitable separation between them and major noise sources; generally prohibit HUD support for new construction of noise-sensitive uses on sites having unacceptable noise exposure; provides a policy on the use if structural and other noise attenuation measures where needed; provides policy to guide implementation of various HUD programs; and recognizes the use the Day-Night Average Sound Level (DNL) to describe noise.

The basic document to implement the noise regulation (24 CFR Part 51B) is the *Noise Guidebook* (HUD, 1985). The Guidebook contains desktop methods for calculating noise levels from aircraft, highways and railroads. It also encourages the HUD field offices and its

clients to rely on the Federal Aviation Administration, airport operators and the Department of Defense for aviation noise data and for land use conformity practices.

2.6 National Aeronautics and Space Administration

NASA's noise reduction program is a major part of NASA's Advanced Subsonic Technology Initiative Program which began in October 1993 to develop technology to ensure that the U.S. aviation industry is prepared to meet the demands placed on the aviation system by growing traffic volume and safety requirements. The goal of the program is to provide noise reduction technology readiness to allow unrestrained market growth, provide increased U.S. market share, and insure compliance with international environmental requirements. The current program plan spans a seven year period. The program approach is designed to develop noise reduction technology in cooperation with U.S. industry and the FAA to enhance growth and competitiveness, while maintaining high efficiency. The technology areas included in the program are engine noise reduction, nacelle aeroacoustics, engine/airframe integration, interior noise reduction, and flight procedures to reduce airport community noise.

The objective of the program will be achieved via systematic development and validation of noise reduction technology. The timing of the technology development will be consistent with the anticipated timing of recommendations for increased stringency in noise standards. There has been a strong coordination among government, industry and academia in the planning of this noise reduction program. This close coordination will continue during the execution of the program to effectively transfer the noise reduction technologies to the U.S. industry.

To achieve the goals of the program, NASA has established an objective of 10 dB noise reduction relative to 1992 technology. This goal will be achieved by a team of industry, university, and government technologists working within a well-established noise technology infrastructure.

The Noise Reduction program objective will be achieved by combined noise reduction improvements in the engine, aircraft system, and in aircraft operations. As seen in Figure 1, the five elements of the noise reduction program are directed toward three desired technology results: engine design for noise reduction, aircraft system noise minimization, and community noise impact minimization. The goals and objectives for each of the elements are given in the sections to follow. Details of specific research tasks, except for the interior noise reduction element, are given in Appendix B.

Engine Noise Reduction

The objective of the engine noise reduction element is to provide technology, by the end of the decade, to reduce engine noise levels 6 dB relative to 1992 technology . The technology will provide design techniques for lowering noise while maintaining high performance for advanced turbofan engines. It will address acoustic, aerodynamic and structural disciplines

and will provide experimental data and analyses that lead to improved low-noise turbofan design methodology. A near term objective for 1996 is to provide technology for reducing jet noise by 3 dB for engines with bypass ratios in the range from 3 to 6. In the same time frame, technology for reducing fan noise 3 dB will be demonstrated in model scale for advanced fan designs with bypass ratios ranging from 6 to 15. Technology for reducing engine noise by 6 dB will be demonstrated in the year 2000.

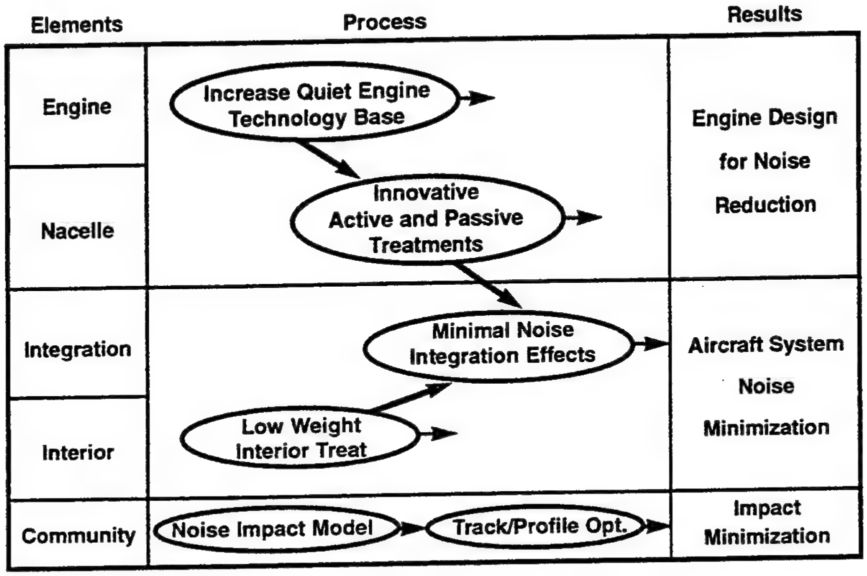

Figure 1. Noise Reduction Technical Approach: Advanced Subsonic Technology Program

Nacelle Aeroacoustics

The goal of this research is to provide technology to increase the effectiveness of the engine nacelle (the housing surrounding the engine) in absorbing, canceling or redirecting turbomachinery noise. Research will include developing and improving analytical models for estimating nacelle geometry effects on noise propagation; conducting laboratory experiments to improve duct noise control treatments including passive, adaptive and active control strategies; and validating noise control technologies through scale model and full scale tests. The ultimate objective is to achieve a 50% increase in suppression effectiveness by the year 2000. An intermediate objective is to increase treatment efficiency by 25% by 1997.

Acoustic/Aerodynamic Integration and System Evaluation

The goal of the integration and system evaluation element is to develop and validate design methods and advanced concepts for low-noise, aerodynamically efficient aircraft. Emphasis is on the acoustic and aerodynamic integration of turbofan engines with high-lift systems for both takeoff/climbout and approach/landing operating conditions. Specific objectives include the capability to reduce airframe noise 4 dB below current levels, eliminate any potential noise penalty due to the interaction of the engine and the wing high-lift system while at least maintaining the current level of high-lift performance, and identify and eliminate areas of risk when model scale experiments are used to predict the performance of flight hardware under flight conditions. An additional objective is to improve the capabilities of the Aircraft Noise Prediction Program (ANOPP) which is used by the industry and NASA for prediction of noise of the total aircraft system.

Interior Noise Reduction

The goal of the interior noise reduction element is to develop and validate weight-efficient technology to minimize cabin and cockpit noise in commercial and general aviation aircraft, including advanced tiltrotors. The objective is to produce technology capable of yielding a 6 dB overall interior noise reduction by the year 2000 without an increase in treatment weight beyond that of current designs.

Community Noise Impact

The goal of the community noise impact element is to provide technology to reduce noise impact of aircraft and airport operations through application of new aircraft technologies and operational procedures, through improved noise impact modeling and prediction, and through improved understanding of relationships between human response and aircraft noise exposure variables. The objective is to provide an equivalent of a 3 dB reduction in noise impact on the community through optimized aircraft and airport operations. A community noise impact minimization model will be developed by 1999 which can be used to determine optimal landing approach and takeoff procedures for various aircraft types at any given airport.

2.7 U.S. National Park Service

The objective of the National Park Service's Aircraft Overflight Research Program has been to answer the major questions posed by Public Law 100-91, the National Park Overflight Act. The two major questions are as follows:

- Is there a proper minimum altitude which should be maintained by aircraft when flying over units of the National Park System? (Subsidiary questions tie to impacts of overflights on on-ground users, impairment of visitor enjoyment, injurious effects of overflights on natural and cultural resources, and values associated with aircraft flights over parks); and

- Have the Special Federal Aviation Regulations (SFAR 50-2) that regulate the airspace over the Grand Canyon succeeded in substantially restoring the natural quiet in that park?

The Secretary of the Interior is to submit a report to the Congress containing the results of this study and can make recommendations for regulatory or legislative action based on the report. A preliminary draft of the Report will go to the Administrator of the Federal Aviation Administration for review. The Administrator will first review the report and its recommendations to see if these cause any adverse effects on aviation safety, and then work with the Secretary of the Interior to resolve these issues. The law makes it clear that the final Report to Congress should include a finding by the Administrator that implementation of the recommendations will not have an adverse effect on the safety of aircraft operations, or if the Administrator is unable to make such a finding, a statement of the reasons why these recommendations will have an adverse effect.

Over 100 parks, nearly a third of all units in the National Park System, have reported aircraft overflights as a management issue.

3. SUMMARY OF RESEARCH PROJECTS

The August 1992 FICON report identified four general topics for additional research: land use compatibility, community reactions, perception, and rotary-wing noise. Current research projects, to the extent they fall within these subject areas, are grouped together in the discussion which follows to provide an overview of the significant Federal interest in these issues. Projects which do not fall within the four categories identified by FICON are consolidated into five supplemental topic areas covering the full breadth of Federal research interests. These additional groupings are: noise reduction technologies, noise effects on animals, noise model developments, public information and education, and structural damage concerns.

Table 2, which continues for several pages, presents a summary of the research projects currently underway within FICAN member agencies.

In the area of *land use compatibility*, the FAA is conducting a study of the effects of airport noise on housing values. Preliminary findings from that study are not conclusive. A final report is expected in late 1994.

Several agencies are conducting research into *community reactions to aircraft noise*. The USA's research generally is focussed on annoyance from intrusive and intermittent sounds such as blasts and sonic booms. The USAF is studying annoyance from aircraft overflights and military training route noise, as well as impulsive noise from helicopters. The USAF and NASA, with assistance from the USA and FAA, are conducting a two-phase study of noise-induced sleep disturbance. Phase I is complete and involved collection of sleep disturbance data in people's homes near civil and military airfields as well as in control locations. The results indicated a relatively low level of sleep disturbance, attributed primarily to habituation. The purpose of Phase II is to collect additional in-home data and develop a dose-response relationship between noise level and sleep disturbance. In response to concern over potential non-auditory health effects, the USAF is investigating the feasibility and design of a prospective epidemiologic study of the effects of aircraft noise exposure on human health, with a specific interest in cardiovascular disease.

In the area of *background noise*, the USAF is conducting a study of the effects of background noise level, onset rate and sound exposure level on human annoyance.

Current research on *rotary wing aircraft* (primarily helicopters) is directed toward the development of improved computer modeling capabilities, primarily by the FAA and USA, the development of low-noise rotor technology (USA) and the reduction of helicopter noise through adjustments to pilot techniques (USA).

Research on *noise effects on animals* is led by the USAF, which is conducting research on the effects of overflights and aircraft noise on domestic, grazing and wild animals, as well as on birds of prey. The USAF also is developing a noise monitor to track noise exposure of wild

and domestic animals. The USA, in conjunction with USAF, is conducting studies of the effect of intermittent noise (explosions) in nesting and roosting eagles, and the effects of military training route noise on desert big horn sheep.

There is significant *noise model development* ongoing at all Federal agencies. The FAA is working on new versions of the Integrated Noise Model (INM, version 5) and Helicopter Noise Model (HNM), and is preparing new models to assess enroute noise (Enroute Aviation Noise Model, or EANM) and to optimize arrival and departure routes beyond the immediate vicinity of airports (Noise Impact Routing System, or NIRS). The USAF is developing and improving several models to predict noise from military training route and military operating area operations (ROUTEMAP, MOA_NMAP, MR_NMAP, ASAN); sonic booms (Boom 10C, PCBoom3, CorBoom, BoomMap3), and long- and short-term noise exposure near military bases (NOISEMAP and SENM). NASA is updating its computer model to predict noise from advanced technology aircraft and operating procedures (ANOPP), and developing a community noise impact model to combine INM and GIS information to minimize airport noise impact on communities (ACIM). NASA, in conjunction with the FAA, is validating the prediction capabilities of INM and NOISEMAP at large distances for which DNL noise exposure is below 60 dB.

NASA is the lead Federal agency for research on *aircraft noise reduction technologies* through the advanced subsonic technology program. The ultimate program objective is a 10 dB reduction in aircraft noise, by the end of the century, relative to 1992 technology. Specific technologies being investigated include: integrated engine and nacelle development, fan noise reduction concepts, active noise control of engines, jet noise reduction, advanced absorptive engine liners, active noise control in engine ducts, airframe/high-lift operational procedures, and aeroacoustic design methodology. USAF research in advanced noise reduction technologies focusses on active noise cancellation, as applied to the following areas: flight demonstrations, engine silencers and hush houses, and earplugs.

In the area of *public information and education,* both the FAA and USAF are developing improved versions of ISIS (Interactive Sound Information System), which replicates photo-quality images and videos of aircraft while simultaneously re-playing high-fidelity recordings of aircraft operations. This tool is used by planners and other agency representatives to educate members of the public about noise created by aircraft operations. In addition, the FAA is preparing an informational brochure describing Day-Night Average Sound Level (DNL) and other acoustic terminology, and sponsoring FICAN public forums to solicit public input in the direction of Federal noise research.

With regard to *structural damage,* the USAF is conducting research on the effects of sonic boom on structures, including both conventional and unconventional structures.

Appendix B presents more detailed descriptions of each project and includes the following information: project title; sponsoring agency; research contact; coordinating agency (if the project is sponsored jointly); purpose; description; schedule; product; and findings, if any.

Table 2. Current Federal Research Topics on Aircraft-Related Noise

Project	Sponsoring Agency	Coordinating Agency(s)	Project Reference Page
Land Use Compatibility:			
Study of the effects of airport noise on housing values	FAA		B-47
Land use compatibility	USAF		
Community Reactions to Aircraft Noise:			
Human annoyance to military training route (MTR) noise	USAF		B-13
Human annoyance to impulsive noise	USAF		B-14
Field study of aircraft noise-induced sleep disturbance	USAF	NASA, USA	B-21
Aircraft noise-induced sleep disturbance	NASA	FAA, USAF	B-69
Comparison of annoyance of sonic booms and weapons blasts	USA	USAF	B-31
Low cost method for investigating complaints about random, intermittent intrusive sounds	USA	USAF	B-32
Psychological rules for cumulative annoyance of different intrusive sounds	USA	USAF	B-33
Interaction between sound and vibration in homeowners' perception of the annoyance of explosions	USA	USAF	B-34
Development of prototype human response monitor (HRM) for collecting field data on human responses to aircraft overflight noise	USAF		B-23
Feasibility assessment of conducting a prospective epidemiologic study of the effects of aircraft noise exposure on human health: Phase I - Noise exposure and population demographics	USAF		B-22
Response to changes in noise exposure	NASA	FAA	B-70
Perception of Aircraft/Background Noise:			
The effects of background noise level, onset rate and sound exposure level on human annoyance in response to aircraft overflight noise	USAF		B-24
National Parks Aircraft Overflight Research Program	NPS		B-74

Project	Sponsoring Agency	Coordinating Agency(s)	Project Reference Page
Rotary-Wing Issues:			
Heliport Noise Model (HNM)	FAA		B-44
Reduction of helicopter sound levels through pilot style	USA		B-35
Low noise rotor technology	USA		B-39
Prediction of helicopter sounds under different meteorological conditions	USA	USAF	B-38
Noise Reduction Technologies:			
Active noise cancellation flight demonstration	USAF		B-26
Active exhaust silencer program	USAF		B-28
Advanced technology active noise reduction initiatives	USAF		B-27
Advanced technology noise reduction (ATANR) earplug	USAF		B-11
Integrated engine and nacelle noise prediction	NASA		B-55
Fan noise reduction concepts	NASA		B-56
Active control of engine noise	NASA		B-57
Jet noise reduction	NASA		B-58
Advanced absorptive liners	NASA		B-59
Active noise control (ANC) in engine ducts	NASA		B-60
Airframe/high-lift noise	NASA		B-62
Installation aeroacoustic design methodology	NASA		B-63
Noise impact minimization	NASA		B-65
Impact of high-lift improvements	NASA		B-66
Impact of alternative operational procedures	NASA		B-67
Aircraft noise reduction and air carrier efficiency	NASA	FAA	B-71
Noise Effects on Animals:			
Determine the effects of aircraft noise on domestic animals	USAF		B-5
The effects of aircraft noise on birds of prey	USAF		B-6
The effects of noise on grazing animals	USAF		B-7

Project	Sponsoring Agency	Coordinating Agency(s)	Project Reference Page
The effects of aircraft overflights on predator-prey relationships	USAF		B-8
Animal noise monitor for aircraft overflights	USAF		B-9
The effects of aircraft noise and sonic booms on the Desert Tortoise	USAF		B-10
The effect of explosions on nesting and roosting eagles	USA	USAF	B-36
Exposure of desert big horn sheep to aircraft sounds	USA	USAF	B-37
Noise Model Developments:			
ROUTEMAP 2.0	USAF		B-12
NOISEMAP	USAF		B-16
Single Event Noise Model (SENM)	USAF		B-17
MOA_NMAP	USAF		B-18
Sonic Boom Modeling	USAF		B-19
Assessment System for Aircraft Noise (ASAN)	USAF		B-25
Noise modeling for military operating areas	USAF		B-18
Integrated Noise Model (INM)	FAA		B-43
Enroute Aviation Noise Model (EANM)	FAA		B-45
Noise Impact Routing System (NIRS)	FAA		B-46
Development of data for accurate computer modeling of sound levels produced by aircraft overflight of National Parks	FAA	NPS	B-52
Airport Community Noise Impact Model (ACNIM)	NASA		B-64
Aircraft Noise Prediction Program (ANOPP) Subsonic Update	NASA		B-61
Validation of aircraft noise models at low exposure levels	NASA	FAA	B-68

Project	Sponsoring Agency	Coordinating Agency(s)	Project Reference Page
Public Information/Education:			
Informational Brochures	FAA		B-49
FICAN public forums	FAA	NASA, USAF, USA ,EPA, HUD	B-51
Informational Videos	FAA		B-50
Multi-media Interactive Sound Information System (ISIS)	FAA		B-48
Multi-media Interactive Sound Information System (ISIS)	USAF		B-15
Structural Damage:			
Sonic boom structural damage assessment	USAF		B-20

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APPENDIX A. FICAN LETTER OF UNDERSTANDING

LETTER OF UNDERSTANDING

FEDERAL INTERAGENCY COMMITTEE

ON

AVIATION NOISE

BACKGROUND:

On March 16, 1993, representatives of the agencies that participated on the Federal Interagency Committee on Noise (FICON) met and agreed to establish a standing committee to be known as the Federal Interagency Committee on Aviation Noise (FICAN). This Letter of Understanding (LOU) defines the purpose, scope, membership, process and products of the FICAN, and formally documents the commitment of the participating agencies.

The Department of Defense (DOD), the Federal Aviation Administration (FAA), and the National Aeronautics and Space Administration (NASA) are the primary agencies responsible for addressing aviation noise impacts through general R&D activities. From time to time, Congress also authorizes agencies such as the National Park Service and the Forest Service to conduct specific aviation noise R&D projects. Each agency is funded to independently carry out its R&D program. Agencies such as the Department of Veteran Affairs and Housing and Urban Development draw on aviation noise R&D products in formulating certain policies. Other agencies including the Environmental Protection Agency, the Council on Environmental Policy, the Council on Historic Preservation and the Department of Justice have mission requirements that require cognizance of aviation noise R&D products.

PURPOSE:

The FICON issued its report in August 1992. One of the FICON recommendations is to *"Increase research (R&D) on methodology development and on the impact of aircraft noise. To foster this, a standing Federal interagency committee should be established to assist agencies in providing adequate forums for discussion of public and private sector proposals, identifying needed research, and in encouraging the conduct of R&D in these areas."*

The purpose of FICAN is to provide the permanent aviation noise R&D forum envisioned in the FICON recommendation.

SCOPE:

The FICAN provides the necessary technical forum for participating agencies to coordinate aviation noise R&D. Other sources of noise will be considered only in relation to aviation noise; i.e., ambient noise and the comparison of impacts of other noise sources with aviation noise. The FICAN will:

- Provide a clearinghouse for Federal aircraft noise R&D;
- Develop recommendations and priorities on needed R&D and noise assessment issues;
- Serve as a focal point for public/private/government questions and recommendations on aviation noise R&D;
- Conduct public conferences on a periodic basis to exchange information on R&D findings, conclusions and new aviation noise topics of public concern; and,
- Establish a network of sources for the accumulation and distribution of technical information on aviation noise to public/private/government entities.

MEMBERSHIP:

Each participating agency will provide appropriate technical representation to all FICAN proceedings. The chair will rotate among the participating agencies on a periodic basis to be determined in initial FICAN proceedings. Any Federal agency may become a FICAN member upon execution of this MOU by a duly authorized official. Each participating agency agrees to provide administrative support commensurate with its level of participation in FICAN either directly, or by contributing funding for a central administrative support contract.

PROCEEDINGS:

The FICAN will maintain a formal agenda of activities scheduled no less than six months into the future. The chair agency will maintain and administer the schedule of activities. The FICAN will periodically hold public meetings (at least annually) to receive recommendations for future R&D efforts and to report on FICAN activities. Working groups comprised of FICAN representatives and other member agency employees or contractors will be formed to address specific issues. Working group products will be fully coordinated among all member agencies before release as a FICAN product.

The FICON Report Recommendation 3.7, Research and Development contains a specific list of issues (attached) recommended for the initial agenda of the FICAN. In addition to this list of issues and recommendations generated from the public sector, each member agency may at any time propose additional issues for the FICAN agenda.

PRODUCTS:

The FICAN products will be in the form of reports, studies, analyses, findings, and conclusions. All products will be fully coordinated with member agencies prior to release or issuance.

In order to insure optimum consistency in Federally sponsored aviation noise R&D, each member agency agrees to apprise FICAN of all ongoing or planned efforts and to coordinate projects where appropriate.

APPENDIX B. RESEARCH PROJECT DESCRIPTIONS

B.1 AIR FORCE PROJECTS

PROJECT TITLE:	Determine the Effects of Aircraft Noise on Domestic Animals
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	To be able to predict the effects of aircraft overflights on domestic animals and, in turn, identify proposed operations that may significantly impact these animals. Once problems are identified, then actions may be proposed to mitigate or avoid potential problems.
DESCRIPTION:	This project involved several steps. 1) We performed a literature review of all the noise and disturbance studies performed on domestic animals of concern to the US Air Force- namely cattle, horses, pigs, sheep, fowl, and fur-bearing animals. 2) Once the literature review was complete, the literature was evaluated to identify technological gaps in the literature that would preclude the development of an effects model to predict the effects of aircraft noise on domestic animals. 3) A model was built to predict the effects of aircraft overflights on domestic animals. The model was divided into three major categories of animals: large stock, domestic fowl, and swine and fur-bearers. Within each category of animal there are subdivisions of the model to predict trauma/injury and production loss (i.e. eggs, meat, hide, etc). There was sufficient information to build interim models for large stock and domestic fowl. Swine and fur-bearing animals were not modeled because of the lack of research on these animals. 4) Research began to fill in the identified gaps of knowledge as funds were made available.

SCHEDULE:

1. Literature review: Completed
2. Identify technological gaps: Completed
3. Develop interim model: Completed
4. Perform research studies
    - Noise effects on pregnant mares: Completed
    - Noise effects on milk yield in dairy cattle: Completed
    - Noise effects on turkey poults: Completed
    - Sonic boom effects on egg hatchability: Completed
    - Probability of trauma in large stock: FY98
    - Startle effects in chickens: FY99
    - Clinical surveys: Unfunded

PRODUCT: An improved domestic animal effects model to be inserted in the Assessment System for Aircraft Noise (ASAN).

PROJECT TITLE:	The Effects of Aircraft Noise on Birds-of-Prey
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
COORDINATING AGENCY:	National Biological Survey and US Fish and Wildlife Service
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	The Air Force will benefit by having a validated model to assess the impact of aircraft noise on raptors. This will greatly assist environmental planners in developing timely EIAP documents and providing answers to questions raised by the general public, USFWS and NPS. Currently, the USFWS can and has stopped proposed actions with formal Section 7 consultations in accordance with the Endangered Species Act. The goal of this project would be to reduce the concerns raised during these formal consultations and speed up the EIAP.
DESCRIPTION:	The technical objective of this project is to develop a validated dose-response model on the effects of aircraft overflights on birds of prey. The technical approach to accomplish the objective will be to perform field studies on species of interest in an attempt to validate the current model. Several tasks will accomplish this objective. Task 1, a study protocol will be developed in cooperation with the USFWS to perform valid field studies to detect differences of 5-30% productivity rates in spite of large variances in nest success. The study design will take into account such factors as habituation rates, prey abundance, and changes in parental behavior that could affect productivity. This first task will examine possible study locations and make a recommendation for the best sites near an Air Force installation to perform such a study. Task 2 will be designed to make observations of aircraft overflights in the vicinity of nesting raptors. This task should be performed over a two year period at a minimum to determine the effects of noise on productivity. Task 3 would attempt to address the effects of aircraft overflight noise on threatened or endangered raptor species, such as Peregrine Falcons and Bald Eagles. This task would form a subset of data obtained from Task 2 where non threatened and non endangered species would be studied. Task 4 will involve making changes to the current dose-response model and inserting the improved model into the latest version of the Assessment System for Aircraft Noise (ASAN). ASAN is a software tool to assist environmental planners assess the impact of aircraft operations on the environment.
SCHEDULE:	Task 1: FY94 Task 2 and 3: FY96 Task 4: FY97
PRODUCT:	A validated raptor effects model to be inserted into the Assessment System for Aircraft Noise (ASAN).

PROJECT TITLE: The Effects of Noise on Grazing Animals

SPONSORING AGENCY: USAF (Armstrong Laboratory)

COORDINATING AGENCY: US Fish and Wildlife Service

CONTACT: Major Robert Kull (513) 255-3605

PURPOSE: To develop a generalizable dose-response model for the effects of aircraft overflights on grazing animals. This model will be used by environmental planners to predict the effects of aircraft noise on the environment.

DESCRIPTION: Many of the lands overflown by USAF aircraft contain prime habitat for grazing animals, both wild and domestic. This projects was developed to focus on potential effects of aircraft overflights on wild grazing animals including bighorn sheep, antelope, elk, and caribou. The project is multi-faceted due to the large variation in the types of animals and their primary locations. The general concept was to study the effects of aircraft overflights on these animals, develop a generalizable model to predict the effects on overflown populations, and then test the model on other species to determine its applicability. Two studies began in 1989. One study was on caribou. Caribou were of interest, not only because they are overflown in Alaskan territories, but because there is a considerable amount of knowledge of their energetics which could contribute to the model. The other study was on Desert Bighorn Sheep. Both studies were similar in that both lab and field studies were performed. In the lab, penned animals were exposed to simulated aircraft overflights while researchers observed the animals' behaviors and physiological responses. In the field, military aircraft were used to create realistic scenarios of what animals could be exposed to. A model was developed to predict the effects of aircraft overflights on caribou. The model must now be tested and validated. Since no populational effects were observed on the bighorn sheep study, no model was developed. Future studies will focus on other species and testing the generalizability of the dose-response model.

SCHEDULE:
Determine priority animals to study: Completed
Perform caribou study: Completed
Perform bighorn sheep study: Completed
Develop dose-response model for caribou: Completed
Perform model validation study: Unfunded
Perform free-ranging bighorn sheep study: Unfunded
Perform antelope study: Unfunded

PRODUCT: A grazing animal dose-response model to be inserted into the Assessment System for Aircraft Noise (ASAN).

PROJECT TITLE: The Effects of Aircraft Overflights on Predator-Prey Relationships

SPONSORING AGENCY: USAF (Armstrong Laboratory)

CONTACT: Major Robert Kull (513) 255-3605

PURPOSE: To study the effects of aircraft overflight noise on a predator-prey relationship in which both the predator and its prey are dependent on hearing for survival.

DESCRIPTION: This study is the first of its kind. Previous noise effects studies focused on one species. However, biologists know that nothing in the environment occurs without affecting other aspects of an ecosystem. It was for this reason that this project set out to investigate the effects of noise on a hearing-dependent predator and its hearing-dependent prey. Investigators decided on using kit fox and its small mammal prey as this predator-prey relationship. The Barry M. Goldwater Bombing Range was selected as prime habitat for these organisms along with sufficient amount of aircraft noise to perform the study. Both a lab and field study were designed. The lab study used simulated aircraft noise to determine if there was any hearing loss immediately after foxes were exposed to an aircraft overflight. The field study surveyed kit fox home ranges in both a controlled environment and an exposed area as well as its small mammal prey, kangaroo rats and other species. Researchers determined the noise levels animals were being exposed to, both on the ground surface and in burrows. Population densities, sizes of home ranges, scat examinations, predator surveys, aircraft noise level sampling were performed over a three year period.

SCHEDULE:
Identify the species and locate suitable study area: Completed
Perform three year field study on aircraft noise effects: FY94
Perform controlled lab study: Completed
Report on findings for effects: FY95

PRODUCT: Report on the effects of aircraft noise on kit fox and its small mammal prey.

PROJECT TITLE:	Animal Noise Monitor for Aircraft Overflight Studies
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	Although researchers have studied the effects of aircraft noise on wild and domestic animals for many years, descriptions of the noise stimuli used in many of the studies was undocumented. Recent technology has allowed the miniaturization of much of the hardware for noise monitor devices, so much so that it was feasible to build a noise monitor for a large animal collar. The purpose of this work is to improve the current prototype animal noise monitor (ANM) by making it more reliable, smaller, and interactive with a global positioning system (GPS).
DESCRIPTION:	This effort set out to build an Animal Noise Monitor that would fit on a large animal collar. The original device was designed to capture A- and C-weighted noise levels above a programmable threshold. The device would also capture onset rate, L_{eq}, and gross movements of the animal after a noise event. Once a prototype was built, the device would be tested on caribou to determine the ANM's reliability and accuracy. Specifications for a production unit ANM would be developed and would include improvements and further miniaturization. With the development of animals collars with GPS systems, it was envisioned to attach the ANM to a GPS-type collar.
SCHEDULE:	Develop ANM prototype: Completed Lab test unit for accuracy: Completed Field test unit on caribou: Completed Develop specifications for production unit: Jun 94 Develop small number of production units: Sep 94 Integrate ANM with GPS collar: FY96 Production of final unit in large quantity: FY96
PRODUCT:	Animal Noise Monitor for large and medium-size animals

PROJECT TITLE:	The Effects of Aircraft Noise and Sonic Booms on the Desert Tortoise
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
COORDINATING AGENCY:	Bureau of Land Management, US Fish and Wildlife Service, and US Army
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	The USAF Flight Test Center at Edwards AFB CA is the location for all flight testing of new USAF aircraft in research and development phases. The Environmental Assessment for testing the F-22 identified that effects of noise and sonic booms from this aircraft on the Desert Tortoise are unknown and recommended for study. The purpose of this effort is to determine if there is any likelihood of noise impacts on the tortoises and provide a report to the System Program Office prior to the F-22 flight test.
DESCRIPTION:	This project involves several phases. First, density and distribution maps for Desert Tortoise in the Edwards AFB area were digitized on a geographical information system (GIS). With the digitized data, we were able to overlay flight track distributions and sonic boom contours in order to determine the levels of exposures of noise and sonic booms to the tortoises. Second, a research protocol must be developed to determine the types of laboratory and field studies to perform in order for us to assess the impact of aircraft overflights to the animals. Behavioral and physiological effects as well as structural effects of sonic booms are being considered as possible impacts. If any potential effects are discovered, then specific mitigative measures will be recommended to the AF Flight Test Center at Edwards AFB for the Biological Assessment.
SCHEDULE:	Contractor Work Plan development: Completed Digitize tortoise density/distribution maps: Completed Research protocol development: May 94 Laboratory and field research: Dec 95 Final report: Dec 95
PRODUCT:	A final report on the effects of aircraft noise and sonic booms on the Desert Tortoise.

PROJECT TITLE:	Advanced Technology Active Noise Reduction (ATANR) Earplug
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	Develop an ATANR system to reduce noise at the eardrum to acceptable levels when the wearer is in a noise environment with free field sound pressure levels of up to 140 dB. Current ANR headsets reduce noise levels of up to 125 dB.
DESCRIPTION:	Integrate two digitally controlled ANR systems developed by the active noise control research group at National Center for Physical Acoustics (NCPA) at the University of Mississippi into a passive ear protector containing an earplug under an earmuff. One system employs a digital control scheme to reduce broad band, random noise at frequencies up to 8 kHz, originally developed for the Navy EX-14 diving helmet. The second system adds a periodic noise reduction capability to the random noise reduction system, originally developed for the Army's ANR stethoscope.
SCHEDULE:	Set up lab facilities: Jun 93 Integrate active periodic noise reduction system: Jun-Sep 93 Integrate active random noise reduction system: Jun-Oct 93 Develop prototype system: Jun 93-Jan 94 Develop headsets: Feb-Mar 94 Final delivery and report: Apr-May 94
PRODUCTS:	Ten Advanced Technology ANR system prototypes.

PROJECT TITLE:	ROUTEMAP 2.0
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	To develop a new version of ROUTEMAP to predict noise impact from Military Training Route (MTR) operations.
DESCRIPTION:	ROUTEMAP is the AF noise exposure model developed for assessing the impact from Military Training Route (MTR) operations. ROUTEMAP was developed out of concern that the noise environment from low-altitude, high speed flyovers was not being addressed. A series of studies examined the noise generated by the aircraft, the flight tract dispersion, and the human annoyance to the overflights. From these studies and other validation efforts, a new and improved methodology has been developed and implemented into ROUTEMAP 2.0.
PURPOSE:	ROUTEMAP assesses the impact of noise generated by aircraft flying along MTRs.
SCHEDULE:	Contractor test and evaluation: Mar 94 In-house test and evaluation: Apr 94 Transition to AFCEE: May 94
PRODUCTS:	ROUTEMAP 2.0

PROJECT TITLE:	Human Annoyance to Military Training Route (MTR) Noise
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	Assess human annoyance to MTR operations on overflown communities.
DESCRIPTION:	A series of studies that have attempted to understand the factors that govern human annoyance to MTR noise. These studies have examine the effect of the following factors on annoyance: sound exposure level, onset rate, sporadicity, number of events, subject activity, and background noise level. Future research efforts will continue to address sporadicity, number of events, the development of long-term annoyance and compatible land usage.
SCHEDULE:	In-house review of Hybrid Own-Home Experiment: Mar 94 Continue in-house research: Mar 94 Seek funding for future studies: Apr 94
PRODUCTS:	Onset rate penalty recommendation used in ROUTEMAP & MR_NMAP.

PROJECT TITLE:	Human Annoyance to Impulsive Noise
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
COORDINATING AGENCY:	NASA-Langley and US Army
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	To assess the annoyance to impulsive noise on impacted communities.
DESCRIPTION:	Evaluate human annoyance to impulsive noise. Specifically the studies will examine annoyance to, sonic booms, blast, artillery, and helicopter noise sources.
SCHEDULE:	Collect high quality sonic boom recordings : Apr 94 Develop Laboratory Impulsive Simulator/Analyzer (LISA): Jun 94 Conduct pilot human response studies: Jul 94 Develop long-term test plan: Sep 94
PRODUCTS:	Prediction of human annoyance to impulsive noise.

PROJECT TITLE:	Multi-Media ISIS
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	Educating USAF planners, pilots, civil engineers, and the public about noise created by AF operations.
DESCRIPTION:	Multi-media ISIS is an improved version of the Interactive Sound Information System (ISIS) which not only can replicate high fidelity sounds, but also photo quality images and video. A prototype was developed in the Windows environment that will ensure capability with future hardware and software advancements. A survey of potential AF users found interest in developing Multi-media ISIS for educating planners, pilots, civil engineers, and the public.
SCHEDULE:	Prototype development: completed Prototype modifications: (unfunded)
PRODUCTS:	Multi-media ISIS for Air Force aircraft

PROJECT TITLE:	NOISEMAP
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	Develop the databases, model, metric, and interpretive criteria used by all DOD (HQ USAF/CEVP, MAJCOMs, National Guard Bureau, Air Force Reserve, Navy/Marine Corps, and Army) to assess the noise impact around military airbases to directly support the Air Installation Compatible Use Zone (AICUZ) program and the DoD mandated Environmental Impact Analysis Process (EIAP) managed within USAF by HQ USAF/CEV assess the impact of noise around military airbases for defense against encroachment and evaluation of base realignment plans.
DESCRIPTION:	Develop and validate a noise exposure model for military airbases to be used in the Air Installation Compatible Use Zone (AICUZ) program and AF EIAP documents. NOISEMAP is the computer program that predicts the total noise exposure around military airbases. This program forms the cornerstone of the AF AICUZ program to stem encroachment around military airbases. Updates to NOISEMAP will include the results of in-house and contractual studies to model special operations (vertical takeoff and landings, hover, etc.), improve propagation modeling, aircraft profile modeling, and improve interpretive criteria for airbase compatible land use planning. Both field and analytical studies will be conducted to assess the effects of local topography and aircraft segment modeling on total noise exposures as well as the attenuation effect of urban terrain on the propagation of sound. Close coordination with the national and international committees (SAE, FICAN, ICAO, etc) on aircraft noise modeling will be maintained to keep DoD current with the state-of-the-art in noise modeling.
SCHEDULE:	NOISEMAP 6.3: Jan 94 Transition to AFCEE: Feb 94 Develop Topography Capabilities: May 94 In-house test and evaluation: Jul 94
PRODUCTS:	NOISEMAP 6.4

PROJECT TITLE:	Single Event Noise Model
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	Public groups and some Federal agencies are pressuring DoD to include single event noise and impulsive noise impact analyses in Environmental Impact Assessment Process (EIAP) documents. This effort is to improve and evaluate a single event noise model (SENM) for aircraft noise. The SENM validation will include noise from subsonic and supersonic aircraft activity. This model will provide a defensible analytical approach to assess single event noise impacts generated by DoD operations and will aid in complying with the National Environmental Policy Act (NEPA). Once the SENM has been validated for aeroacoustics, the next stage will be to rehost the program to a workstation platform for use by DoD. This effort will examine the atmospheric turbulence effects studied under the Army SERDP proposal, incorporate specific propagation algorithms for turbulent atmospheres into the SENM, and validate the results with field measurements
DESCRIPTION:	Develop and validate a single event high resolution noise prediction program for aircraft overflights. SENM is a ray trace program that will calculate the instantaneous noise levels from a proposed aircraft over flight including the effects of non homogenous atmospheric conditions and varying wind conditions. This program is based on the underwater acoustics program used by the Navy for identifying enemy submarines. The underwater acoustics equations will be converted into aeroacoustic equations. This effort will directly support the tri-service strategic plan for the compliance pillar of research and development objective of developing improved assessment tools related to environmental management. This will assist DoD in producing defensible EIAP documents concerning noise generated in sensitive areas such as parks and wilderness areas. This effort will address rising public concerns about single event impacts and enhance compliance to NEPA. A secondary benefit is to provide a detection capability and support the High Speed Civil Transport program. The results of this effort will be used by the US Navy, Air National Guard, and the Air Force Reserve in their Environmental Assessments.
SCHEDULE:	SENM working prototype: May 94 Validation with AL/OEBN noise data: Feb 94 Develop Workstation version: Unfunded Atmospheric Turbulence Effects: Unfunded
PRODUCTS:	Single Event Aircraft Noise Model

PROJECT TITLE:	Noise Contouring for Military Operations Areas
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	Develop the databases, model, metric, and interpretive criteria used by all DoD (HQ USAF/CEVP, MAJCOMs, National Guard Bureau, Air Force Reserve, Navy/Marine Corps, and Army) to assess the noise impact from all subsonic military aircraft flights in non airbase environments for the DoD mandated Environmental Impact Analysis Process (EIAP)
DESCRIPTION:	Noise exposure model for subsonic aircraft in Ranges, Routes, and Military Operating Areas for use in developing Air Force Environmental Assessments. MR_NMAP is a PC-based computer model that has been developed to calculate the noise levels under MOAs, Ranges, and Routes. The program allows the user to draw the airspace, specify areas of High, medium, or low activity, and draw specific tracks used in the airspace. The program also can specify avoidance areas within the MOA that the pilots are to fly around. The program calculates L_{dn}, L_{eq}, SEL, L_{max}, and where appropriate L_{dnmr}. The program output is a tabular form or in graphics suitable for inclusion in EIAP documents. MR_NMAP models the noise by separating the operations into categories that are then individually modeled. Most operations in a MOA tend to be distributed over the airspace or confined to specific tracks. Superimposed on these randomly distributed operations are MTRs and bombing run patterns. Each of these is modeled separately in MR_NMAP and summed together to develop the composite noise contours.
SCHEDULE:	Develop MR_NMAP: Mar 94 Measure MOA noise environment: Mar 94 Validate against measurements: May 94 In-house test and evaluation: Aug 94 Transition to AFCEE: Sep 94
PRODUCTS:	Noise prediction and noise contouring software program (MR_NMAP)

PROJECT TITLE:	Sonic Boom Modeling
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	These models allow researchers and environmental planners to analyze the environmental impact of supersonic operations, to design supersonic profiles to minimize sonic boom impacts to noise sensitive areas, to investigate sonic boom damage claims, to analyze sonic boom data collected in the field, and to study sonic boom generation and propagation.
DESCRIPTION:	Current sonic boom models involve prediction schemes for both single- and multiple-event boom scenarios. For single sonic boom predictions, we have two models, BOOM10C and PCBoom3. BOOM10C is based on Carlson's method (NASA TP 1122) and provides peak overpressure and duration estimates for booms generated by steady-state supersonic flight conditions. PCBoom 3 utilizes full ray theory to predict sonic boom propagation produced by supersonic military aircraft. This program allows a user to input aircraft, weather, and flight data in order to generate a flight profile. Next the sonic boom overpressure and signature are predicted for the given flight profile. The sonic boom overpressures are then plotted out as either footprints or contours to demonstrate the ground regions which will be impacted by the supersonic operation. For multiple boom environments we also have two models, CorBoom and BoomMap 3. CorBoom predicts the yearly average boom levels, Lcdn, for supersonic operations along a corridor. BoomMap 3 predicts the Lcdn contours for supersonic operations in air combat maneuvering instrument areas (ACMI). This program uses the ACMI tracking data to predict the sonic boom environment. Both of these programs used a simplified ray tracing algorithm developed by Dr Kenneth Plotkin of Wyle Laboratories.
SCHEDULE:	PCBoom 3 Beta version delivered by: 21 Mar 94 PCBoom 3 Validation Test : 4-15 Apr 94 BoomMap 3 version 1.00 Release: Nov 93
PRODUCTS:	BOOM10C: (available) PCBoom 3: (release date: July 94) CorBoom: (available) BoomMap 3: (available)

PROJECT TITLE:	Sonic Boom Structural Damage Assessment
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	This research allows better assessment of possible sonic boom damage to structures, so that supersonic operations my be planned to minimize damage claims. Also, the assessment system will permit environmental planners to assess structures which may be susceptible to sonic boom induced damage.
DESCRIPTION:	Sonic booms can cause property damage in structures. For conventional structures, this damage usually results in broken window panes and bric-a-brac and cracks in plaster wall. For unconventional structures, such as historical buildings, adobes, etc., sonic booms can cause damage by adding to environmental stress levels. The possibility of sonic boom damage is evaluated in two ways, single event boom impacts and cumulative boom impacts. For a single boom impact, models exists for glass, plaster, and bric-a-brac. With these models, the estimated peak overpressure probability distribution is input, and the model predicts the probability of damage. A similar model exists for unconventional structures but is very generalized due to the unique dynamics of these types of structures. As for cumulative damage, we have recently completed a study on plaster walls exposed to >5000 booms. From this study, damage levels produced by sonic booms were shown to be minimal. Also, we are working on developing a structural assessment system for sonic boom impacts. This system will include both computer models and experimental measures. The experimental measurement system will use shaker and speakers to measure the transient response of a structure, either unconventional or conventional, so that its response to sonic boom can be predicted. This assessment will calculate the sonic boom levels needed to exceed damage thresholds within the structure.
SCHEDULE:	Cumulative sonic boom damage to plaster walls: 1993 Cumulative sonic boom damage to glass: 1995 Assessment system for structures, Phase I: Dec 1993 Phase II: June 1996
PRODUCTS:	Single Event Damage Models for Glass, Plaster, and Bric-a-brac Unconventional Structure Damage Thresholds Cumulative Damage Experimental Results for Plaster Walls Prototype Assessment System for Structures

PROJECT TITLE:	Field Study of Aircraft Noise-Induced Sleep Disturbance
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
COORDINATING AGENCY:	NASA-Langley and US Army
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	This study was conducted to explore previously reported discrepancies between the amount of sleep disturbance from environmental noise, particularly aircraft overflight noise, observed in laboratory versus field studies.
DESCRIPTION:	An in-home, field study of nighttime sleep disturbance was conducted at three locations in California: a U.S. Air Force base, the Los Angeles International Airport and several control sites. Both outdoor and indoor measurements of sound exposure were taken to describe the noise exposure of the participants. Sleep disturbance was indicated by having the study participants press a button near their bed whenever they were awakened. In addition, a brief questionnaire was administered at night and in the morning. A total of 1887 subject-nights of data were collected from 45 homes. Sleep disturbance was related to individual aircraft overflight events, using Sound Exposure Level as the noise metric. The results indicated a very low level of sleep disturbance at all levels of exposure (less than 10% awakenings). Since the observed levels of awakening were considerably lower than what has typically been reported from laboratory studies, it is possible that habituation plays a much greater role for in-home awakening from aircraft overflight noise than has generally been assumed. This might be especially true for behavioral indicators of awakening, such as a button-press response, as compared to more traditional physiological indicators of awakening. Because of their objectivity and ease of interpretation, the former are currently preferred for use in environmental policy considerations.
SCHEDULE:	The present project was started in October 1992 and completed in February 1994. At the present time, the final report is being prepared for publication.
PRODUCTS:	Final report

PROJECT TITLE:	Feasibility Assessment of Conducting a Prospective Epidemiologic Study of the Effects of Aircraft Noise Exposure on Human Health: Phase I - Noise Exposure and Population Demographics
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	Field research data are needed to determine the level of risk to human health from exposure to aircraft overflight noise. Some international researchers, particularly those from Germany, have published data indicating that a significant risk exists. However, virtually all of the relevant studies published to date have had serious methodological problems and questionable results. Most prominent researchers in this area believe that a prospective epidemiologic research design is the only acceptable methodology to address the issue of health effects from exposure to aircraft noise. This research design involves a long-term, field study of many individuals (perhaps as many as 10,000 to 12,000) over a minimum five-year period of time. Low, medium and high exposure groups in the UK will be sought for inclusion in the prospective epidemiologic study if the feasibility study demonstrated that such an effort is both technical feasible and cost-effective.
DESCRIPTION:	The U.S. Air Force, the Canadian National Defence Headquarters, and the United Kingdom Ministry of Defence have implemented a tri-national study to determine the feasibility of conducting a prospective epidemiologic field study of the effects of military aircraft noise, particularly that from low-altitude, high speed training flights, on human health. The human health issues of greatest concern in the current international scientific literature involve factors relating to cardiovascular disease. This study is being implemented in the United Kingdom because of their large concentration of populations under military aircraft flight training corridors. The initial phase of this effort involves identifying population centers exposed to aircraft overflight noise and an estimate of their annual exposure. A geographic information system (GIS) has been developed to provide this modeling capability, although data are currently available only for one area of the country. The next phase will complete the population and noise exposure databases, provide an estimate of the magnitude of the noise exposure problem in the whole of the UK, and will identify specific sites that might be used as experimental and control (High and Low Exposure) sites.
SCHEDULE:	Feasibility study Phase I report: FY94 Feasibility study Phase II: FY95 Epidemiologic study begins: FY96 Final Report: FY02
PRODUCTS:	Final reports with recommendations to proceed to next phase.

PROJECT TITLE:	Development of Prototype Human Response Monitor (HRM) for Collecting Field Data on Human Responses to Aircraft Overflight Noise
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	The HRM will be used to collect real-time noise exposure and human response data in a variety of field research projects on the effects of aircraft noise. Two primary research thrusts are planned that require use of this device. The first addresses sleep disturbance due to nighttime aircraft noise exposure. The second addresses issues related to annoyance from aircraft overflight noise under Military Training Routes and near Military Operations Areas. The focus of this second area of research will be on the effects of infrequent and unpredictable operations on annoyance.
DESCRIPTION:	This project involves the development of a prototype miniaturized HRM for use in research on human responses to aircraft overflight noise. The HRM will be capable of collecting both real-time noise exposure data and questionnaire-type human response data. Virtually any time of hierarchical questionnaire will be able to be programmed into the HRM, making it useful in a wide range of field research projects where it is not feasible or cost-effective to have a researcher present for the data collection. This will be especially useful in projects where data are sought on long-term human responses, ranging from several weeks to several months. The HRM will consist of state-of-the-art analog and digital signal processing and data management components. Because the HRM will be a small, lightweight, but very powerful microcomputer, it will provide a field research data collection technology nor previously available in the environmental noise arena.
SCHEDULE:	Concept development: 1988 Project start: 1992 Prototype delivered: 1994 Initial production: 1995
PRODUCTS:	Two prototype HRMs will be developed, along with the documentation required for a preliminary production run and for further developmental work.

PROJECT TITLE: The Effects of Background Noise Level, Onset Rate and Sound Exposure Level on Human Annoyance in Response to Aircraft Overflight Noise

SPONSORING AGENCY: USAF (Armstrong Laboratory)

CONTACT: Major Robert Kull (513) 255-3605

PURPOSE: The primary purpose of this experiment was to explore the relationship between the level of an intrusive noise event and the background noise level against which it is heard (i.e., the signal to noise ratio). This issue is being investigated in order to determine whether current noise effects prediction models (such as the well-known Schultz curve) need to be modified to include a measure of the background noise level. SEL and event onset rate were included primarily to validate the results of earlier studies and because these two variables were expected to have stronger relationships with annoyance than the background level was expected to have. While it is certainly true that, at the one extreme, complete "masking" of an intrusive noise event will occur in areas with high background noise levels (such as near rivers in parks), it is not known whether a corresponding "contrast effect" occurs when there is a large difference between the intrusive noise level and the background noise level. A "contrast effect" would make a given level of noise exposure more annoying as the difference between the intrusive event and the background level increases (i.e., more contrast between the two). In addition, very little is known about how annoyance is related to the signal-to-noise ratio in between the extremes where "masking" and a "contrast effect" would occur. Information on this topic is needed to address environmental noise policy issues for areas such as national parks, wilderness areas and small general aviation airports; all of which are areas with low background noise levels.

DESCRIPTION: The project is part of a series of laboratory experiments to address technical parameters of aircraft noise exposure that affect judgments of human annoyance in response to this exposure. The study participants rated their subjective annoyance in response to individual aircraft overflight events, which were produced using a high-fidelity sound simulation system in a semi-echoic chamber. The overflights were typical of those experienced under Military Training Routes with low-altitude, high speed flight training operations. Parameters varied in this study included Sound Exposure Level (SEL), background noise level and event onset rate. Preliminary results indicate a typical strong effects of SEL and onset rate, validating previous published results. The remainder of the data analysis, including examining the effects of background noise level, still remains to be done.

SCHEDULE: Lab studY: 1993
Final report: 1994

PRODUCTS: Final report

PROJECT TITLE:	Assessment System for Aircraft Noise (ASAN)
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	The USAF has had serious difficulties in getting critical Environmental Impact Statements (EISs) approved for various Military Training Routes and Military Operations Areas in a timely manner. ASAN will greatly reduce the amount of time required to prepare analyses and documentation required by NEPA. It will also provide the USAF with a standard methodology to calculate the expected noise environment from USAF flight training operations and to predict the effect this noise will have on humans, animals and structures.
DESCRIPTION:	ASAN is a computer based system designed to assess the environmental impacts of noise and sonic booms developed from USAF aircraft flying low level missions on Military Training Routes (MTR) and supersonic missions in Military Operations Area (MOA) respectively. ASAN first calculates the expected noise generated by the USAF aircraft performing training missions, then it predicts the effects this noise will have on humans, animals and structures using USAF approved noise effects models. It provides the USAF environmental, community, and route planners and airspace managers the capability to produce technically and legally defensible environmental impact analyses prepared in compliance with the National Environmental Policy Act (NEPA) of 1969. ASAN requires a workstation to operate.
SCHEDULE:	ASAN release 1.0: FY94 Version updates: yearly
PRODUCTS:	Assessment System for Aircraft Noise software and recommended hardware for implementation

PROJECT TITLE:	Active Noise Cancellation Flight Demonstration
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
COORDINATING AGENCY:	NASA-Lewis
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	The objective of this effort is to reduce acoustic interior and flyover noise levels of military and civilian propeller driven aircraft by using the noise of one engine under digital control to actively acoustically cancel the noise of another engine.
DESCRIPTION:	This project is the development and inflight demonstration of a digital phase locked active noise cancellation system for multi-engine propeller driven aircraft.
SCHEDULE:	Hardware Design and Fabrication: Jan-May 94 Laboratory Testing: May-Jun 94 Flight Tests (Military Aircraft): Jul-Aug 94 Initial Flight Test Report: Sep 94
PRODUCTS:	Final report

PROJECT TITLE:	Advanced Technology Active Noise Reduction Initiatives
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	Hush houses and jet engine test cells are designed for substantial reduction of the noise exposure in the neighborhood of these test facilities. Both facilities have one or two air inlet silencers and a lined augmenter tube that serves as an exhaust silencer. The air inlet silencers are usually of the conventional parallel baffle type which provide efficient sound attenuation for engine inlet noise which is of predominately high frequency noise. To address the low frequency noise which is of higher energy and potentially could damage surrounding structures and annoy individuals, an innovation active control approach to enhancing acoustic performance of exhaust silencers would work synergistically with existing passive systems. The result would be significantly reduced noise in the lower frequency range where passive liners are ineffective.
DESCRIPTION:	Evaluate the feasibility of Active Noise Reduction through the use of a high-intensity, air modulated, noise source to control the noise from hush houses and engine test cells, and for an area localized control of the noise from unsurpressed jet engines. The initial tests will be conducted under controlled conditions at an engine test facility. The results of these tests will be applied in a hush house noise reduction demonstration at an Air Force facility.
SCHEDULE:	Project start: Jul 93 DemonstratioN: Aug 94 Final report: Sep 94
PRODUCTS:	Final report

PROJECT TITLE:	Active Exhaust Silencer Program
SPONSORING AGENCY:	USAF (Armstrong Laboratory)
CONTACT:	Major Robert Kull (513) 255-3605
PURPOSE:	Hush houses and jet engine test cells are designed for substantial reduction of the noise exposure in the neighborhood of these test facilities. Both facilities have one or two air inlet silencers and a lined augmenter tube that serves as an exhaust silencer. The air inlet silencers are usually of the conventional parallel baffle type which provide efficient sound attenuation for engine inlet noise which is of predominately high frequency noise. To address the low frequency noise which is of higher energy and potentially could damage surrounding structures and annoy individuals, an innovation active control approach to enhancing acoustic performance of exhaust silencers would work synergistically with existing passive systems. The result would be significantly reduced noise in the lower frequency range where passive liners are ineffective.
DESCRIPTION:	Conduct a proof of concept Active Noise Reduction for noise reduction in the operation of hush houses and jet engine test cells. The program is viewed as a three phase program. Phase I includes the development of system, subsystems and hardware requirements. Phase II includes design, acquisition or fabrication of hardware, and Phase III will include the test and evaluation of the system. As part of the third phase, the Active Noise reduction system will be tested with a 1/4 scale exhaust silencer with the results leading to a risk assessment focusing on the full scale problem. The active portion of the system consists of a series of noise sources within the augmenter tube that are controlled to reduce the input impedance of the backing chamber and thereby enabling the absorptive liner to be effective at low frequencies.
SCHEDULE:	Project start: Jul 93 1/4 scale demonstration: May 94 Final report: July 94
PRODUCTS:	Final report

B.2 ARMY PROJECTS

PROJECT TITLE:	Comparison of Annoyance of Sonic Booms and Weapons Blasts
SPONSORING AGENCY:	US Army (Construction Engineering Research Laboratory)
COORDINATING AGENCY(S):	USAF (Armstrong Laboratory)
CONTACT:	Dr. Paul D. Schomer, (800) 872-2375
PURPOSE:	To collect data on annoyance from people exposed to supersonic operations, and determine if previous prediction models are accurate.
DESCRIPTION:	In providing a sonic boom assessment procedure for use in the U.S., the National Academy of Sciences Committee on Hearing, Bioacoustics and Biomechanics (CHABA, 1981) and American National Standards Institute (ANSI, 1988) assumed that community response to sonic booms, large guns and surface mining explosions are similar enough to allow the response data to be pooled. However, there has never been a test to establish whether these sources are truly equivalent in annoyance. The only place where such a test can be conducted is in a supersonic military flight corridor. Subjects in real houses will judge the annoyance of sonic booms and detonations of explosives to see (1) whether they discriminate between the sources and (2) whether the C-weighted Sound Exposure Level predicts annoyance accurately.
SCHEDULE:	Study is planned but unfunded at this time.
PRODUCT:	Evidence on whether knowledge gained by the Army about the effects of its tank and artillery blasts on residential neighbors can be extrapolated to assessments for citizens living in sonic boom corridors.

PROJECT TITLE:	Low Cost Method for Investigating Complaints about Random, Intermittent Intrusive Sounds.
SPONSORING AGENCY:	US Army (Construction Engineering Research Laboratory)
COORDINATING AGENCY(S):	USAF (Armstrong Laboratory), USArmy (USAEHA)
CONTACT:	Dr. Paul D. Schomer, (800) 872-2375
PURPOSE:	To develop a portable, low-cost computer/questionnaire to collect data on annoyance.
DESCRIPTION:	Analyses of complaints about aircraft noise received by the Air Force and Army have shown that complaints are generated by intermittent, random intrusive sounds rather than long term average exposure. Such complaints are expensive to investigate because military installations rarely have persons who can wait with a sound level meter for days or weeks at a complainant's home to ascertain the conjunction of operational and meteorological conditions responsible for the disturbance. Low cost monitors, such as those envisioned by the USEPA in their 1974 "Levels Document" are available from several vendors, but complaint investigation also requires data on annoyance registered simultaneously with the noise measurements. A low cost (under $300) commercial computer has been programmed with a short annoyance questionnaire. Small enough to be carried about the house in a pocket or on a belt, the device records the time when activated and provides the user with a menu for different noises. The device also provides an option for log in/out and a button for recording sleep disturbance.
SCHEDULE:	Initial user tests were conducted in February 1993 with occupants of military quarters at Fort McNair exposed to National Airport noise. An improved version was used in an Air Force sleep disturbance study in 1993. Tests with blast noise complainants were conducted in early 1994.
PRODUCT:	A low cost method for identifying noises that citizens find particularly intrusive or annoying.

PROJECT TITLE:	Psychological Rules for Cumulative Annoyance of Different Intrusive Sounds
SPONSORING AGENCY:	US Army (Construction Engineering Research Laboratory)
COORDINATING AGENCY(S):	USAF (Armstrong Laboratory), US Army (USAEHA)
CONTACT:	Dr. Paul D. Schomer, (800) 872-2375
PURPOSE:	To collect data and develop algorithms for predicting cumulative annoyance from a variety of noise sources.
DESCRIPTION:	Previous Army research has established that people tend to rate a real-life sound as more annoying than an artificial sound of the same, A-weighted decibel level when they listen to these sounds inside a real house. However, no one has established the rules by which people add up the annoyance of different kinds of sound into a judgement of the annoyance of a total day's exposure. These rules are particularly important for NEPA actions in areas where citizens are exposed to the noise of two branches of the Armed Services, such as Cape Cod, where citizens enjoined the Massachusetts National Guard to assess the joint impact of noise from Otis Air Force Base and Camp Edwards. In Phase 1 of this study, citizens living in the vicinity of a railroad and of an Army helicopter flight corridor will be asked to rate the annoyance of individual sounds along with each day's exposure. Annoyance ratings will be correlated with noise measurements collected at the same time.
SCHEDULE:	Phase 1 is scheduled to begin in FY94. Funding for additional phases has not been identified at this time.
PRODUCTS:	Algorithms for predicting the cumulative annoyance from aircraft and other military noise sources in noise-exposed areas.

PROJECT TITLE:	Interaction between Sound and Vibration in Homeowners' Perceptions of the Annoyance of Explosions
SPONSORING AGENCY:	US Army (Army Environmental Hygiene Agency)
COORDINATING AGENCY(S):	US Army (Construction Engineering Research Laboratory), USAF (Armstrong Laboratory)
CONTACT:	Dr. George A. Luz, (410) 671-3797
PURPOSE:	To investigate the relationship between measured and perceived sound and vibration levels.
DESCRIPTION:	Measurements of explosive noise, wall vibration, corner vibration and ground vibration were made at the homes of eight complainants living on the east shore of the Chesapeake Bay across from heavy weapons testing at Aberdeen Proving Ground on the west shore. During measurements, homeowners were given an opportunity to register their perception of the annoyance of individual blasts (on a 5 point scale) along with whether they heard windows rattle or felt walls shaking. Responses will be analyzed to test an earlier Army hypothesis that the annoyance of explosions increases dramatically when the sound is accompanied by window rattle or other building vibrations.
SCHEDULE:	Final report expected in FY95.
PRODUCT:	Potentially useful information for mitigating complaints from homeowners living in the vicinity of sonic boom corridors.

PROJECT TITLE:	Reduction of Helicopter Sound Levels through Pilot Style
SPONSORING AGENCY:	US Army (Construction Engineering Research Laboratory)
COORDINATING AGENCY(S):	US Army (USAEHA)
CONTACT:	Dr. Larry L. Pater, (800) 872-2375
PURPOSE:	To develop a new set of guidelines and noise abatement flight procedures for Army helicopters.
DESCRIPTION:	Experts in aeroacoustics have known for several decades that the way a pilot flies a helicopter will vary the intensity of sound heard by ground observers. To encourage pilots to fly in ways that minimize disturbance to residents living in flight corridors, the Army Aviation Support Agency provides copies of a publication from the Helicopter Association International, Fly Neighborly. However, the guidelines in this publication were developed for Vietnam-era helicopters using acoustical equipment that is technologically-obsolete. The intent of this research is to develop a new set of Fly Neighborly guidelines. In Phase 1, a UH-1H was flown in various patterns to determine whether the Fly Neighborly guidelines for this helicopter are still applicable.
SCHEDULE:	Analysis of data taken on the UH-1H in June 1993 has been delayed because of loss of personnel. Additional phases of this work have not been funded.
PRODUCT:	A revised set of guidelines for newer Army helicopters (UH-60A, AH-64, OH-58D, CH-47D).

PROJECT TITLE:	The Effect of Explosions on Nesting and Roosting Eagles
SPONSORING AGENCY:	US Army (Environmental Hygiene Agency)
COORDINATING AGENCY(S):	USAF (Armstrong Laboratory), US Army (Construction Engineering Research Laboratory)
CONTACT:	Mr. William A. Russell, Jr., (800) 872-2375
PURPOSE:	To document blast levels in areas where eagles are successfully nesting and roosting, for use in determining tolerance levels.
DESCRIPTION:	Automated noise monitors have been set up at bald eagle nests and roosts at Aberdeen Proving Ground, Maryland, in areas subjected to the sounds of large guns. These sounds are similar in intensity to sonic booms. By documenting the blast levels in areas where eagles are successfully nesting and roosting, the Department of Defense can determine whether the intensity of sonic booms and weapons blasts at eagle nesting and roosting sites should be restricted.
SCHEDULE:	To be completed in FY95.
PRODUCT:	Report specifying intensities of explosive noise tolerated by bald eagles with no adverse effect on breeding.

PROJECT TITLE:	Exposure of Desert Big Horn Sheep to Aircraft Sounds
SPONSORING AGENCY:	US Army (Environmental Hygiene Agency)
COORDINATING AGENCY(S):	USAF (Armstrong Laboratory), U.S. Fish and Wildlife Service, New Mexico Fish and Wildlife Service.
CONTACT:	Mr. William A. Russell, Jr., (800) 872-2375
PURPOSE:	To document noise exposure levels under military flight paths in areas of desert big horn sheep habitat.
DESCRIPTION:	Automated noise monitors have been set up under flight paths used by transient Air Force aircraft in areas of White Sands Missile Range and White Sands National Monument forming the habitat of desert big horn sheep. These flights paths are used only during a DoD training exercise, JTX Roving Sands, held in May. Sound exposures measured by the equipment are adjusted for the assumed audiometric sensitivity of this species and provided to State and Federal wildlife officials as part of the ongoing NEPA documentation. These officials then determine whether there has been any adverse consequences associated with the documented noise exposure.
SCHEDULE:	Reports on JTX Roving Sands held in 1992 and 1993 have been published as internal Army documents. Additional monitoring is anticipated for April 1994.
PRODUCT:	Documentation in support of National Environmental Policy Act and Endangered Species Act.

PROJECT TITLE:	Prediction of Helicopter Sounds under Different Meteorological Conditions
SPONSORING AGENCY:	US Army (Construction Engineering Research Laboratory)
COORDINATING AGENCY(S):	USAF (Armstrong Laboratory), US Army (Environmental Hygiene Agency)
CONTACT:	Dr. Michael J. White, (800) 872-2375
PURPOSE:	To improve the prediction of helicopter noise by coupling an improved mathematical procedure with a faster way to obtain output from this procedure.
DESCRIPTION:	The improved mathematical procedure, Fast Field Program or FFP, uses the same meteorological data on wind speed, wind direction and temperature at different altitudes to predict propagation as does an older procedure (sound ray tracing). The difference is that FFP yields more accurate predictions than sound ray tracing. The major disadvantage is that FFP requires a supercomputer to complete the calculation within a reasonable period. To get around this disadvantage, Army physicists have created a library of typical cases to allow software to match a set of meteorological conditions with stored FFP calculation for a similar set of meteorological conditions. The software used to make the match is called LOOKUP. The research consists of testing whether the loss of precision from using LOOKUP is a reasonable tradeoff for the faster access to FFP.
SCHEDULE:	A successful test was conducted at Alamogordo, New Mexico, in August 1993 with participation of Danish, English, German and Norwegian scientists under the auspices of the NATO Committee for Challenges to Modern Society. The test showed that the predictive capability could be improved further by incorporating algorithms for the influence of atmospheric turbulence on sound propagation. However, this additional work has not been funded.
PRODUCT:	Algorithms to be incorporated into computer models for airfield noise predictions that would allow predictions to be adjusted for local weather.

PROJECT TITLE:	Low Noise Rotor Technology
SPONSORING AGENCY:	US Army (Aviation and Troop Command, ATCOM)
COORDINATING AGENCY(S):	USArmy (Aeroflightdynamics Directorate)
CONTACT:	Dr. Yung H. Yu, (415) 604-5834
PURPOSE:	To develop innovative blade concepts for reduction of noise radiation generated by a rotorcraft, which will minimize the chances for detection of the rotorcraft during penetration of hostile airspace, thus increasing the likelihood of successful mission effectiveness.
DESCRIPTION:	Modern helicopters radiate an intense, low frequency impulsive noise that is easily detectable by acoustic detection systems or smart acoustic mines. Rapid increase in capabilities of these ground-based air defense systems to detect, track, and identify a rotorcraft poses a growing threat for US combat helicopters. The technology challenges include the development of innovative blade airfoil/planform shapes and also advanced active blade control techniques using smart materials/structures. Technology barriers include the conflicting fundamental requirements of noise-generating mechanisms and rotorcraft performance. The risk to find an optimum resolution between these conflicting requirements of noise and performance is significant, but not insurmountable. With careful planning with insightful knowledge, the objective can be accomplished.
SCHEDULE:	A comprehensive prediction capability is developed to investigate the effects of blade design concepts in the acoustic radiation and rotor performance. Various design concepts are being evaluated in small scale model tests. More emphasis is being placed on the active blade control concepts with smart structures.
PRODUCT:	A validated analytical prediction CFD code will be developed. Optimum blade planform shapes and active blade control concepts will be developed for less noise without performance degradation. This research benefits the public living near military and commercial airfields by reducing the overall noise level of helicopter operations.

B.3 FEDERAL AVIATION ADMINISTRATION PROJECTS

PROJECT TITLE:	Integrated Noise Model (INM)
SPONSORING AGENCY:	FAA (Office of Environment and Energy)
CONTACT:	Dr. Jake Plante, (202) 267-3539
PURPOSE:	To determine the noise impact of decisions affecting the growth and effective use of airport capacity.
DESCRIPTION:	The Integrated Noise Model (INM) is the FAA's standard for aircraft noise analysis as defined by FAA Order 1050.1D, Policies and Procedures for Considering Environmental Impacts; Order 5050.4A, Airport Environmental Handbook; and Federal Aviation Regulations (FAR) Part 150, Airport Noise Compatibility Planning. Improvements to INM lead to the development of policies and operational procedures for mitigating community impacts. The INM is currently being redesigned and reprogrammed to increase the model's speed and ease of use. The redesign for INM includes Windows NT 32-bit processing and graphical user interface, geographical information (GIS) displays, a system database structure, and data input and management aids. The model will be available on both PC and workstation platforms. Other enhancements include the ability to calculate changes of exposure and population impacts within specified areas (as recommended by the Federal Interagency Committee on Noise - FICON), and to construct user-defined aircraft performance profiles, and to use terminal radar data to build INM tracks.
SCHEDULE:	Version 5 PC release: Fall 1994 Version 5 workstation release: Early 1995
PRODUCTS:	INM Version 5.0, computer noise model, for PC and workstation

PROJECT TITLE:	Heliport Noise Model (HNM)
SPONSORING AGENCY:	FAA (Office of Environment and Energy)
CONTACT:	Ms. Donna Warren, (202) 267-3571
PURPOSE:	To enhance and continue development of the HNM for use in assessing rotorcraft noise impacts and their effects on heliport and airport capacity improvements.
DESCRIPTION:	The Heliport Noise Model (HNM) is the FAA's standard tool for the analysis and prediction of helicopter noise per FAA Order 1050.1D, Policies and Procedures for Considering Environmental Impacts, Order 5050.4A, Airport Environmental Handbook; and Federal Aviation Regulations (FAR) Part 150, Airport Noise Compatibility Planning, which was expanded in 1988 to include heliports. Enhancements to the HNM include improved algorithms based on noise certification test data. Plans in the future include new round of helicopter field testing to acquire additional performance data, integration of the HNM with the Integrated Noise Model (INM), use of the U.S. Air Force NMPLOT contouring routine, use of additional SEL-based noise metrics, and development of new algorithms for terrain effects, vegetation and meteorology. The model has been distributed to over 250 users worldwide.
SCHEDULE:	HNM Version 2.2 release: February 1994 Helicopter noise measurement test: Fall 1994 Prototype joint HNM/INM: FY95
PRODUCTS:	HNM Version 2.2, computer noise model HNM Version 3.0, computer noise model HNM/INM, computer noise model

PROJECT TITLE: Enroute Aviation Noise Model (EANM)

SPONSORING AGENCY: FAA (Office of Environment and Energy)

CONTACT: Mr. John Gulding, (202) 267-3654

PURPOSE: To develop the Enroute Aviation Noise Model (EANM) to analyze alternative aircraft route scenarios and to measure their noise impacts within transitional, TRACON and enroute environments.

DESCRIPTION: As part of the FAA's charter to ensure an efficient aviation system, the evaluation of aircraft noise impacts in the terminal and enroute airspace environments is becoming essential to the identification of realistic air traffic alternatives that can be effectively implemented. By identifying environmentally sound alternatives early in the planning process, operational efforts to increase capacity and improve the efficient flow of traffic can be achieved more effectively. The existing Integrated Noise Model (INM) focuses on computing aircraft noise impacts in the vicinity of an airport. There is a developing requirement for an extension of INM capabilities into the enroute environment to compute noise impacts over large areas, for flights at altitudes between 3,000 and 18,000 feet. New equations extending and modifying the Integrated Noise Model (INM) will be developed to enable the prediction of noise exposure on population from enroute flight paths. Software will be written to extract data from ARTS and SAR radar to analyze flight tracks, from the USGS to analyze terrain effects, and from the Bureau of Census to analyze population and demographic subcategories. The software will be capable of overlaying, on computer screen or hard copy, 3-D information on flight paths, topography, population noise impacts and other factors.

SCHEDULE: Prototype release: Spring 1995

PRODUCT: EANM, computer noise model

PROJECT TITLE:	Noise Impact Routing System (NIRS)
SPONSORING AGENCY:	FAA (Office of Environment and Energy)
CONTACT:	Mr. John Gulding, (202) 267-3654
PURPOSE:	To provide optimization technology and methods in the TRACON and enroute environments creating and evaluating alternatives for noise-minimum arrival and departure routes and procedures.
DESCRIPTION:	While noise impacts historically have been in the vicinity of airports, recent issues have surfaced involving the transitional enroute environment and remote areas. Consequently, in order to make significant improvements in system capacity and efficiency, aircraft noise needs to be considered in the initial design of new air traffic routes and airspace procedures. The FAA is developing optimization technology that can be employed in the early stages of airspace planning to generate and compare individual routes or route networks that seek to minimize the number of people exposed to noise. Number and type of operations, census population data, traffic routings, and Air Traffic Control (ATC) rules and procedures serve as inputs to the model. The optimization techniques produce a desired balance between minimum noise and user constraints (e.g., efficiency and fuel burn, ATC procedures, restricted air space, etc.). NIRS supports existing and planned enroute noise assessment tools through its use of optimization techniques and its application of streamlined methodologies for generating noise values.
SCHEDULE:	Project start: 1993 Airport application for International Civil Aviation Organization: 1994 Ongoing development effort: 1994
PRODUCT/ APPLICATION:	NIRS will be capable of use by air traffic personnel, providing a flexible planning tool to find optimum solutions that are responsive to numerous operational, procedural, and system constraints.

PROJECT TITLE:	Study of the Effects of Airport Noise on Housing Values
SPONSORING AGENCY:	FAA (Office of Environment and Energy)
CONTACT:	Mr. Jim Littleton, (202) 267-3579
PURPOSE:	To determine if the impact of airport noise on housing values can be quantified in monetary terms.
DESCRIPTION:	Issues surrounding airport noise and it's effect on people living near airports has received significant attention from Congress and the Federal Aviation Administration(FAA). Various interests have called for legislation and regulations that would restrict the number and timing of flights operating at airports throughout the nation. Community concerns about airport noise continue to generate a need for the FAA to assess community noise effects and to examine land use alternatives. The objectives of this task is to establish a reliable methodology for determining housing value effects and to quantify the impact of airport noise on housing values in monetary terms. In 1990, the FAA began to look at property values as they relate to aircraft noise. FAA initiated pilot studies at three airport locations to quantify the relationship between aircraft noise and housing values. Two approaches were employed to measure impact: (1) an analytical process using property appraisals; and (2) a modeling approach. The appraisal process involved the identification of two neighborhoods with similar characteristics except for noise levels, then the selection of sample houses to normalize individual house characteristics. Housing values were then compared in the two neighborhoods. The second approach (linear regression model) used the appraised value as the dependent variable and individual housing characteristics as the independent variables. Preliminary findings indicate that the appraisal methodology demonstrates a relationship between housing values and aircraft noise, while the modeling approach produced mixed results. Further research is recommended.
SCHEDULE:	Pilot studies: Complete Final report: Fall 1994
PRODUCT/ APPLICATION:	Findings to be used for policy and planning purposes.

PROJECT TITLE:	Interactive Sound Information System (ISIS)
SPONSORING AGENCY:	FAA (Office of Environment and Energy)
CONTACT:	Mr. Robert Hixson, (202) 267-3565
PURPOSE:	To inform the public about aircraft noise characteristics and how the effects of aviation noise upon the public are perceived.
DESCRIPTION:	ISIS is a computer driven airport noise simulation device using digital recording to accurately reproduce the sounds of aircraft on approach and departure from airports. It was designed to support the FAR Part 150 Airport Noise Compatibility Planning Program. All aircraft sounds reproduced by ISIS are single events. ISIS sound reproduction capabilities include landing and takeoffs for the most currently used passenger aircraft, the ability to compare the noise of various aircraft, and the ability to aurally illustrate the noise of aircraft single events at various locations around an airport. The latter capability is effective for illustrating varying levels of sound proofing and for showing the changes in DNL caused by adding or removing various aircraft operations from a given runway. The model is currently undergoing an evaluation to determine future development.
SCHEDULE:	Current development and evaluation: Fall 1994
PRODUCT:	Public information tool to help the public better understand the characteristic of aircraft noise.

PROJECT TITLE:	DNL Brochure
SPONSORING AGENCY:	FAA (Office of Environment and Energy)
CONTACT:	Mr. Robert Hixson, (202) 267-3565
PURPOSE:	Develop a brochure explaining the Day-Night Average Sound Level (DNL), as used in Noise Compatibility Programs developed under Federal Aviation Regulation, Part 150.
DESCRIPTION:	Federal Aviation Regulation, Part 150, designates the Day-Night Average Sound Level (DNL) as the noise metric to be used in determining the impacts of aviation noise in Part 150 Noise Compatibility Programs. Although easily comprehensible by persons with technical backgrounds, the DNL has been notably confusing to lay persons, including many in decision-making capacity relative to noise abatement. The brochures designed to give the general public a clear understanding of DNL and exactly what noise exposure expressed in DNL means to individuals and their daily activities.
SCHEDULE:	June 1994
PRODUCT:	An educational brochure for distribution to assist in understanding DNL and characteristics of aircraft noise.

PROJECT TITLE:	Instructional Videos
SPONSORING AGENCY:	FAA (Office of Environment and Energy)
CONTACT:	Mr. Robert Hixson / Ms.Patricia Cline, (202) 267-3565 / (202) 267-3562
PURPOSE:	Develop educational videos for the public and instructional videos to train FAA personnel about aviation environmental issues.
DESCRIPTION:	Currently two videotapes are being produced. First, a videotape explaining noise metrics (Lmax, SEL and DNL) and how the metrics are used to produced DNL contours from the INM, followed by a specifically designed ISIS presentation (see page B-48). The video will contain comparisons of Stage 2 and Stage 3 single noise events and a description of the methodology used to graphically produce the DNL at a given listening point. It will show how varying the number of events and the mix of aircraft types changes the DNL. The tape would also clearly demonstrate the benefits of sound insulation and show some actual footage (from an ongoing project) of how sound insulation is installed. Second, a videotape will alert FAA middle managers to environmental issues within the Federal government as a whole, and within FAA in particular. It will also briefly describe the range of services which the Office of Environment and Energy can offer to managers to help them comply with environmental laws and policies and suggest the next steps which managers may take in learning more about environmental regulations and the work of AEE.
SCHEDULE:	Late 1994
PRODUCT:	Educational and instructional videos for distribution to assist in understanding DNL and to alert FAA managers about environmental issues within FAA.

PROJECT TITLE:	FICAN Public Forums
SPONSORING AGENCY:	FAA (Office of Environment and Energy)
CONTACT:	Mr. Tom Connor, (202) 267-3570
PURPOSE:	To solicit input from interested members of the general public regarding the direction of aviation noise research funded by Federal agencies.
DESCRIPTION:	FICAN intends to hold annual public forums to solicit input from interested members of the general public concerning aviation noise and the direction such persons would like to see research funds allocated.
SCHEDULE:	First FICAN public forum: July 1994
PRODUCT:	Input from the public concerning aviation noise research.

PROJECT TITLE: Development of Data for Accurate Computer Modeling of Sound Levels Produced by Aircraft Overflights of National Parks

SPONSORING AGENCY: FAA (Office of Environment and Energy)

COORDINATING AGENCY: NPS

CONTACT: Mr. Jim Littleton, (202) 267-3579

PURPOSE: To provide estimates of aircraft sound levels that may be compared with data that show how park visitors respond to different levels of overflight sound.

DESCRIPTION: The FAA and NPS are working cooperatively to examine the effects of aircraft overflights on National Parks. Public Law (100-91) requires NPS to investigate the effects os aircraft overflights on National Parks. One earlier study that was conducted in response to the this law is the "dose-response" study to develop a quantitative relationship between the sound produced by aircraft overflights (the dose) and the reactions of visitors (the response) to this sound. The dose-response relationships developed under this earlier project provide a tool that can be used to help reduce overflight impacts. As part of the effort, both the FAA and the NPS are developing computer programs that are designed to estimate sound levels produced on the ground by aircraft flying over the park. This project will assist in the development and validation of the FAA and NPS computer models that compute the sound levels produced by aircraft overflights of National Parks. Another objective is to develop new dose-response relationships that will permit assessment of the impacts of aircraft overflights using predictive noise measures.

SCHEDULE: Grand Canyon Noise Measurement Program: May 1994
Report on findings: June 1994

PRODUCTS: Final report
Improved noise prediction and assessment algorithms

B.4 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PROJECTS

PROJECT TITLE:	Integrated Engine and Nacelle Noise Prediction
SPONSORING AGENCY:	NASA
CONTACT:	Dennis L. Huff, NASA Lewis Research Center, (216) 433-3913
PURPOSE:	The purpose of this effort is to develop an acoustic analysis code that can be used to design low-noise turbofan engines.
DESCRIPTION:	A computer code has been developed that predicts the tone noise that results from fan wakes interacting with stators (outlet guide vanes, struts or inlet guide vanes to the engine core). These interactions are considered one of the major noise sources in both current and future turbofan engines. The source code is based on modal analysis of the nacelle duct and models both circumferential and radial modes. It will be upgraded to include rotor/stator coupling, which will model reflection/transmission effects from acoustic waves passing through the fan and stators. A code has also been developed that models the radiation of the source noise to the far field. This includes a liner model that estimates the suppression from acoustic treatment in the nacelle, and reflection/refraction effects that result from the fan nozzle shear layer. Work is now underway to integrate both of these computer codes, which will provide an integrated system noise prediction model for turbofan engines.
SCHEDULE:	Source code and inlet radiation code are already available Integrated system prediction codes: September 1994
PRODUCTS:	Turbofan source and radiation prediction code for analysis or low-noise design.

PROJECT TITLE:	Fan Noise Reduction Concepts
SPONSORING AGENCY:	NASA
CONTACT:	Dennis L. Huff, NASA Lewis Research Center, (216) 433-3913
PURPOSE:	This work will identify and confirm low-noise fan/nacelle concepts that reduce the engine noise 3 dB relative to 1992 technology.
DESCRIPTION:	Various low-noise fan/nacelle concepts will be investigated in model scale wind tunnel testing. The designs will be guided by state-of-the-art acoustic and aerodynamic analyses to accomplish the 3 dB noise reduction goal while maintaining high propulsion efficiencies. Acoustic data will be obtained that assess the low-noise design and provide benchmark data for code validation. Some of the concepts being pursued include a low tip speed fan, swept/leaned fans and stators, fan wake reduction techniques, and a high blade count fan that shifts the rotor tones beyond the audible range. While the emphasis of this work is on lowering fan noise, data that evaluates aerodynamic efficiencies and structural integrity of the integrated fan/nacelle system will also be obtained. Most of the models being tested are candidate designs for future engines. Acoustic, aerodynamic and structural scaling will be addressed by comparing results with company-supplied engine data.
SCHEDULE:	Swept fan test: September 1994 Low tip speed fan test: September 1995 Technology available to meet 3 dB goal: September 1996
PRODUCTS:	Several fan designs with confirmed acoustic benefits Data for acoustic, aerodynamic and structural code validation Identification of promising concepts for follow-on work

PROJECT TITLE:	Active Control of Engine Fan Noise
SPONSORING AGENCY:	NASA
CONTACT:	Laurence Heidelberg, NASA Lewis Research Center, (216) 433-3859
PURPOSE:	Active noise control will be pursued to investigate the acoustic benefits from removing specific fan tones and will be applied to both current and future engines.
DESCRIPTION:	Active noise control is one of the newest technologies available for application to fan noise reduction. This work will concentrate on active control at the source, as opposed to active absorption or cancellation on the duct after the source has been established. The work planned in this area include proof-of-concept laboratory tests, analytical simulations, and actuator/control development for engine applications. Most of the emphasis will be given to the laboratory experiments to demonstrate active control concepts. A large low-speed fan will be used in an acoustic environment that simulates relevant engine frequencies and will be an inexpensive way to test many of the concepts currently identified by researchers. Promising concepts will then be applied to engine tests for final assessment of the acoustic benefits.
SCHEDULE:	Annular cascade test: June 1995 Large low-speed fan tests: September 1996 Concepts confirmed in engine demonstrations: September 1997
PRODUCTS:	Concepts, actuators/control systems, and analyses for designing active noise control systems for turbofan engines.

PROJECT TITLE:	Jet Noise Reduction
SPONSORING AGENCY:	NASA
CONTACT:	Gene Krejsa, NASA Lewis Research Center, (216) 433-3951
PURPOSE:	The objective of this work is to provide technology for reducing jet noise 3 dB relative to 1992 technology.
DESCRIPTION:	Many of the current engines have bypass ratios that are low enough to make jet noise a problem. The work performed here will develop analytical and design methodology for reducing jet noise for engines with bypass ratios of 1.5 to 6. The goal is to show, through model scale testing, a 3 dB reduction in noise levels relative to 1992 technology. Initially, mixers from engines like the JT8D and those used as a part of a previous NASA program (E-Cubed) will be evaluated using current prediction tools and the jet noise levels will be determined experimentally. This will establish baselines for developing improved jet noise prediction systems and aid the design of advanced mixers to meet the noise reduction goals. Promising advanced mixer designs will be tested in an anechoic environment to confirm reduced noise levels.
SCHEDULE:	Improved jet noise prediction: September 1995 Technology available to meet goal: September 1996
PRODUCTS:	Concepts, analyses and design tools for reducing jet noise for both current and future turbofan engines.

PROJECT TITLE: Advanced Absorptive Liners

SPONSORING AGENCY: NASA

CONTACT: Joe W. Posey, NASA Langley Research Center, (804) 864-7686

PURPOSE: The purpose of this effort is to develop new, more efficient technology for sound-absorbing liners in turbofan engine ducts.

DESCRIPTION: While improved fan design is expected to reduce noise generation by no more than 6 dB, a total reduction of 10 dB is desired in radiated noise levels. At least part of the last 4 dB could come from more efficient noise absorption within the nacelle. Absorptive liner investigations will include both broadband passive liner concepts and adaptive liner schemes which would permit in situ adjustment of liner properties. Several liner concepts are being investigated which promise to provide the absorptive properties of bulk absorbers like fiberglass matting, but in a configuration suitable for the environment of engine ducts. Adaptive control concepts are also being explored which could adjust the absorption spectra in situ so that optimal liner properties can be obtained for both takeoff and landing. Adaptive control could also permit in situ corrections of liner properties needed because of manufacturing variances. Liner concepts found to display desired acoustic properties in analytical and small scale experimental studies will be tested in model fan rigs and possibly in full-scale engine tests for validation.

SCHEDULE: Select concepts for large scale validation: September 1996
Full-scale validation: September 1999

PRODUCTS: Validated passive and adaptive treatment concepts to improve broadband and tonal absorption efficiency by 25%

PROJECT TITLE:	Active Noise Control (ANC) in Engine Ducts
SPONSORING AGENCY:	NASA
CONTACT:	Joe W. Posey, NASA Langley Research Center, (804) 864-7686
PURPOSE:	The purpose of this effort is to develop active control technology for fan-generated noise in turbofan engine ducts.
DESCRIPTION:	While improved fan design is expected to reduce noise generation by no more than 6 dB, a total reduction of 10 dB is desired in radiated noise levels. At least part of the last 4 dB could come from the application of active control technology within the nacelle. The feasibility of active control of fan noise has been demonstrated in the laboratory on small turbofan engines. Current work is addressing technology barriers to the construction of a flight-worthy system. These barriers include compact, efficient sound sources, durable sound sensors, and control systems capable of globally controlling far-field noise, given practical limitations in error sensor location and in the complexity and spatial extent of secondary sound sources. This effort will culminate in the demonstration of fan noise control by a flight-worthy active system on a large turbofan engine.
SCHEDULE:	Choose flight-worthy ANC concept for large engine: September 1997 Validate flight-worthy system: September 1999
PRODUCTS:	Validated, flight-worthy ANC technology for in-duct cancellation of ducted-fan noise

PROJECT TITLE:	Aircraft Noise Prediction Program (ANOPP) Subsonic Update
SPONSORING AGENCY:	NASA
CONTACT:	Robert A. Golub, NASA Langley Research Center, (804) 864-5281
PURPOSE:	The purpose of this effort is to develop an updated version of ANOPP to enable accurate far-field noise predictions for certification and community noise assessments of advanced technology aircraft powerplants, advanced aerodynamic aircraft designs, and operating procedures.
DESCRIPTION:	An improved ANOPP prediction code for higher bypass ratio engines (high thrust levels), advanced aircraft aerodynamic designs and advanced operating procedures will be developed. Updated prediction capabilities will include new code modules for fan and turbomachinery noise, jet noise, core noise, and airframe noise. The code will be able to calculate EPNL values for all certification points and produce DNL contours using advanced operating procedures. A special set of developed subroutines will allow the calculation of noise level-thrust data for conceptual aircraft which are compatible with the FAA Integrated Noise Model (INM). These results can then be used with the INM program to calculate DNL contours with the conceptual aircraft noise impact included in the airport community noise assessment. Code module updates will also be accomplished to ensure applicability to general aviation aircraft with lower bypass engines with thrust up to about 10,000 pounds.
SCHEDULE:	Initial prediction model update; Fan noise module: January 1995 Validated prediction model, including turbomachinery, jet, core and airframe noise updates: March 2000
PRODUCTS:	Updated ANOPP prediction code applicable to higher bypass engines, advanced aircraft aerodynamic designs and advanced operating procedures. Improved ANOPP code for General Aviation Aircraft

PROJECT TITLE:	Airframe/High-Lift Noise
SPONSORING AGENCY:	NASA
CONTACT:	Victor R. Corsiglia, NASA Ames Research Center, (415) 604-6720
PURPOSE:	Improve methodology for predicting airframe noise and develop design concepts for providing reduced airframe noise.
DESCRIPTION:	Current methods of predicting airframe noise will be reviewed and compared with available database. Small scale experiments will be conducted by NASA and Industry to produce additional database upon which to further improve airframe noise prediction methodology. Some experiments will be conducted at high Reynolds Number using large-scale models to establish scale effects. Small-scale tests will be conducted to explore concepts for reducing airframe noise. Promising concepts will be validated at large-scale and high Reynolds number.
SCHEDULE:	Large-scale, high Reynolds number scale effects established for aerodynamic/acoustic integration: March 1998 Technology for acoustic and aerodynamic performance validated at large scale: June 2000
PRODUCTS:	Database and validated methodology for predicting and reducing airframe noise

PROJECT TITLE:	Installation Aeroacoustic Design Methodology
SPONSORING AGENCY:	NASA
CONTACT:	Victor R. Corsiglia, NASA Ames Research Center, (415) 604-6720
PURPOSE:	Develop and validate design concepts for the integrated design of wing, high-lift system and the engine.
DESCRIPTION:	Aerodynamic and acoustic studies will be performed of the high-lift system integrated into a wing with an engine installed with the objective of maintaining high lift and lift/drag and minimizing the airframe noise. Both small scale and large-scale tests will be conducted. CFD studies will focus on the aerodynamic flowfield.
SCHEDULE:	Large-scale-high Reynolds number scale effects established for aerodynamic/acoustic integration: March 1998 Technology for acoustic and aerodynamic performance validated at large scale: June 2000
PRODUCTS:	Database and validated methodology for high-lift engine-airframe design

PROJECT TITLE:	Airport Community Noise Impact Model (ACNIM)
SPONSORING AGENCY:	NASA
CONTACT:	Clemans A. Powell, NASA Langley Research Center, (804) 864-3640
PURPOSE:	The purpose of this effort is to develop a computer model for predicting and minimizing the impact of aircraft noise on airport communities.
DESCRIPTION:	A model will be developed which will couple the prediction of noise exposure in airport communities with the exposed population to determine probable effects or impact. The noise exposure prediction will use the latest version of the FAA's Integrated Noise Model (INM). Coupling to population will be accomplished using the GRASS Geographical Information System and the latest census information data base. The model will use relationships that have been developed between noise exposure and the expected human responses of general annoyance, sleep disturbance, complaints, speech interference and health effects to predict the total impact on the community. Optimization algorithms will be developed for determining flight tracts, profiles and schedules that minimize the noise impact for specified aircraft operations.
SCHEDULE:	Initial impact prediction model release: September 1996 Validated impact prediction and minimization methodology: September 1999
PRODUCTS:	ACNIM computer noise impact model ACNIMM computer noise impact minimization model

PROJECT TITLE:	Noise Impact Minimization
SPONSORING AGENCY:	NASA
CONTACT:	Clemans A. Powell, NASA Langley Research Center, (804) 864-3640
PURPOSE:	The purpose of this effort is to evaluate the potential of using advanced flight guidance techniques for reducing aircraft community noise impact.
DESCRIPTION:	Advanced Flight Management Systems (FMS), Geographic Positioning Systems (GPS) and high speed digital communication systems (Datalink) provide the capability to perform visual flight rule (VFR) type noise abatement procedures under instrument flight rule (IFR) conditions. This effort will evaluate noise minimal procedure using advanced FMS, GPS and Datalink technologies using a systems analysis approach that considers three factors; noise, guidance and navigation constraints, and operational constraints. Guidance and operational constraints include the accuracy limits of GPS and other navigational systems, and the aircraft performance limits. Operational limits include pilot acceptance of and confidence in complex maneuvers. Flight simulator studies will be used to examine pilot reaction. This study is to be conducted through a three year grant and will serve as a Ph.D. dissertation topic.
SCHEDULE:	Initiated, August 1993 Noise minimal trajectories identified: August 1994 Initial simulator studies conducted: January -August 1995 Project complete: August 1996
PRODUCT:	Research reports and Ph.D. dissertation

PROJECT TITLE:	Impact of High-Lift Improvements
SPONSORING AGENCY:	NASA
COORDINATING AGENCY:	FAA
CONTACT:	Kevin P Shepherd, NASA Langley Research Center, (808) 864-3583
PURPOSE:	The purpose of this effort is to define the potential noise impact reduction due to assumed improvements in aerodynamic performance of aircraft using advanced high-lift systems.
DESCRIPTION:	An analytical study will be conducted to investigate the potential for reductions in aircraft community noise exposure through the use of advanced high-lift systems on transport aircraft. Airplane configurations, such as small twin , medium twin and large four engine transports, will be selected to represent current transport airplanes. Realistic aerodynamic performance will be assumed for the representative airplane types. Noise levels at FAR-36 certification points and community noise contours will be calculated for the reference configurations and for various levels of high-lift system performance. The high-lift performance improvements will be specified in terms of percent increase in lift-to-drag ratio, etc. The relationship of noise impact reduction to increments in performance will be developed to document the noise benefits.
SCHEDULE:	Initiation of study: March 1994 Completion of study: December 1994
PRODUCT:	Technical report on study findings

PROJECT TITLE:	Impact of Alternative Operational Procedures
SPONSORING AGENCY:	NASA
COORDINATING AGENCY:	FAA
CONTACT:	Kevin P Shepherd, NASA Langley Research Center, (808) 864-3583
PURPOSE:	The purpose of this effort is to quantify the potential community noise reduction of new takeoff and landing operational procedures made possible through the use of advanced high-lift and automated flight and thrust management systems.
DESCRIPTION:	Noise reduction benefits will be estimated for advanced takeoff and landing procedures for subsonic aircraft. Operational procedures will be selected which are within the constraints of safety and within the capabilities of advanced high-lift and automated flight and thrust management systems. Noise reductions will be quantified for four different engine-type/ aircraft-type combinations. The estimated noise reductions will be quantified on the basis of noise contours and FAR-36 noise certification measurement points.
SCHEDULE:	Initiation of study: March 1994 Completion of study: December 1994
PRODUCT:	Technical report on study findings

PROJECT TITLE: Validation of Aircraft Noise Models at Low Exposure Levels

SPONSORING AGENCY: NASA

COORDINATING AGENCY: FAA

CONTACT: Kevin P Shepherd, NASA Langley Research Center, (808) 864-3583

PURPOSE: The purpose of this effort is to examine and validate the prediction capabilities of current airport noise exposure models at large distances for which DNL noise exposure is at or below 60 dB.

DESCRIPTION: The most commonly used analytical capabilities to predict noise exposure in airport communities are Integrated Noise Model (INM) and NOISEMAP which were developed by the FAA and USAF, respectively. Both models calculate noise exposure levels relatively near airports where Day-Night Average Sound Levels (DNL) are generally 65 dB or greater. This contract effort will examine the algorithms used in INM and NOISEMAP for propagation to various distances and for adjustments for finite flight path segments. The algorithms will be compared with each other and with alternative theoretical formulations. A test plan will be prepared to validate the models and a measurement program will be conducted. Measurements will be compared with predictions using both standard and actual flight profile data. Differences will be determined and recommendations for revisions to prediction algorithms and flight profiles will be made.

SCHEDULE: Program initiation: April 1994
Noise measurements complete: December 1994
Final report: July 1995

PRODUCTS: Final report
Revised noise algorithms

PROJECT TITLE:	Aircraft Noise Induced Sleep Disturbance
SPONSORING AGENCY:	NASA
COORDINATING AGENCIES:	FAA, USAF
CONTACT:	Kevin P Shepherd, NASA Langley Research Center, (808) 864-3583
PURPOSE:	The purpose of this effort is to determine a dosage-response relationship between aircraft noise exposure and sleep disturbance
DESCRIPTION:	Several recent community studies have been conducted to provide information on effects of aircraft noise on sleep disturbance. However, because of different measures used to determine arousal or awakenings and different noise measurement locations, indoors or out-of-doors, the results of the two studies can not be directly compared nor pooled to provide increased statistical confidence. The present study is being conducted using both sleep disturbance measurement techniques and noise measurement locations simultaneously. The study is being conducted in the vicinity of a major civilian airport. The first phase has recently been completed and obtained data from 30 houses, 2 resident per house, for 4 weeks. Noise exposure was varied by selecting homes at different distances from the airport. Another phase of data collection is planned in the near future.
SCHEDULE:	Phase I data collection: February - March, 1994 Phase II data collection: May - July, 1994 Final report: March 1994
PRODUCT:	Research report

PROJECT TITLE:	Response to Changes in Noise Exposure
SPONSORING AGENCY:	NASA
COORDINATING AGENCY:	FAA
CONTACT:	Kevin P. Shepherd, NASA Langley Research Center, (804) 864-3583
PURPOSE:	The purpose of this effort is to determine the effects that long-term and short-term changes in aircraft noise exposure have on attitudinal response of community residents.
DESCRIPTION:	Little information , other than anecdotal, is available which will allow prediction in the change in community annoyance to aircraft noise when the noise environment itself is changing. Such information is needed for optimum use of preferential runway systems (short-term change) and planning for major route restructuring (long-term change). The initial contract effort will evaluate what information is available and develop a research plan to obtain necessary additional information. The review will include reaction to changed noise environments in addition to aircraft noise environments. Research goal will be defined through discussions with the NASA, the FAA , airport operators, airport planners and the interested parties. It is envisioned that subsequent efforts will include a number of community surveys in areas where substantial changes in the noise environment is planned and/or routinely occur.
SCHEDULE:	Initial research plan complete: January 1995 Response relationships to changed noise environments developed: September, 1997
PRODUCT:	Research reports for each phase of effort

PROJECT TITLE:	Aircraft Noise Reduction and Air Carrier Efficiency
SPONSORING AGENCY:	NASA
COORDINATING AGENCY:	FAA
CONTACT:	Paul McGowan, NASA Langley Research Center, (804) 864-4350
PURPOSE:	The purpose of the effort is to evaluate economic benefits to air carriers from operating significantly less noisy aircraft.
DESCRIPTION:	Operation of less noisy commercial aircraft could yield economic benefits to air carriers by removing the constraints of time consuming noise abatement procedures and curfews. These could provide economic benefits by reducing block times and by increasing aircraft utilization and airport capacity, respectively. This contract activity will identify the economic and operating effects of current restrictions and perform cost/benefit analyses for public and business carriers operating aircraft from the highest volume U.S. airports at selected noise level reductions. The analyses will be extended to major foreign airports in a second phase if the methodology proves viable.
SCHEDULE:	Implementation plan developed: May 1994 Study complete: December 1994
PRODUCT:	Final study report

B.5 NATIONAL PARK SERVICE PROJECTS

PROJECT TITLE: National Parks Aircraft Overflight Research Program

SPONSORING AGENCY: NPS

CONTACT: Dr. Wes Henry (202) 208-5211

PURPOSE: Public Law 100-91, the National Parks Overflight Act, requires the Secretary of the Interior to conduct a study to determine the appropriate minimum altitude for aircraft flying over units of the National Park System. The law specifically asks that the report address safety issues, impairment of visitor enjoyment, injurious effects of overflights on natural and cultural resources and the benefits of overflights. The law also requires NPS to report on whether Special Federal Aviation Regulations (SFAR) developed for the Grand Canyon have succeeded in substantially restoring natural quiet in the Grand Canyon with a view to recommending revisions to the SFAR.

DESCRIPTION: The NPS has completed a variety of studies including literature surveys on cultural and wildlife impacts, a white paper on the relationship between altitude and aircraft sound, acoustic profiles from a variety of parks (including Grand Canyon, Hawaii, and other parks), dose-response studies in Grand Canyon and Hawaii, and surveys of visitors, managers and air tour passengers. The NPS also has developed a planning/modelling module for use with their geographic information systems.

SCHEDULE: Report to Congress on NPS aircraft overflight research

PRODUCT: Draft/Final Reports that will provide answers to the questions posed by Congress which may make regulatory or legislative recommendations.

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APPENDIX C. GLOSSARY OF TERMS AND ABBREVIATIONS

C.1 ABBREVIATIONS AND ACRONYMS

%HA	Symbol for Percent Highly Annoyed
AAMRL	Armstrong Aerospace Medical Research Laboratory, known as Armstrong Laboratory USAF)
AL/OEBN	Armstrong Laboratory, Noise Effects Branch (USAF)
AEM	Area Equivalent Method
AFB	Air Force Base
AICUZ	Air Installation Compatible Use Zone
ANSI	American National Standard Institute
ASNA	Aviation Safety and Noise Institute
ATCOM	US Army Aviation and Troop Command
CAB	Civil Aeronautics Board
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CHABA	Committee on Hearing, Bioacoustics, and Biomechanics (of the National Academy of Science
CNEL	Community Noise Equivalent Level (used in California)
dB	Decibel
DNL	Day-Night Average A-Weighted Sound Level
DoD	(U.S.) Department of Defense
DOT	(U.S.) Department of Transportation
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	(U.S.) Environmental Protection Agency
FAA	(U.S. DOT) Federal Aviation Administration
FAR	Federal Aviation Regulations
FICAN	Federal Interagency Committee on Aviation Noise (1993)
FICON	Federal Interagency Committee on Noise (1992)
GIS	Geographic Information System
HNM	Helicopter Noise Model (FAA)
HUD	(U.S.) Department of Housing and Urban Development
Hz	Hertz (formerly cycles/second)
INM	Integrated Noise Model (FAA)
Ldn	Symbol for Day-Night Average A-Weighted Sound Level (DNL)
Leq	Equivalent Continuous A-Weighted Sound Level (DNL)
Leq(24)	Equivalent Sound Level during a 24 hour time period
Leq(x)	Equivalent Sound Level during a given time period
L_{max}	A-weighted Maximum Sound Level
NCA	Noise Control Act
NEPA	National Environmental Policy Act
NIHL	Noise-Induced Hearing Loss
NIOSH	National Instutute for Occupational Safety and Health
NIPTS	Noise-Induced Permanent Threshold Shift
NIRS	Noise Impact Routing System (FAA)
NITTS	Noise-Induced Temporary Threshold Shift
NOISEMAP	DoD Noise Model

NSBIT	Noise and Sonic Boom Impact Technology (Air Force Armstrong Laboratory)
SEL	Sound Exposure Level
SLUCM	Standard Land Use Coding Manual
SPL	Sound Pressure Level
TA	Time Above
USAEHA	US Army Environmental Hygiene Agency
USAF	United States Air Force
USGS	U.S. Geological Survey
YDNL	Yearly Day-Night Average A-Weighted Sound Level
USA	United Stated Army

C.2 DEFINITIONS

Sound. Acoustic oscillation capable of exciting the sensation of hearing.

Noise. Any disagreeable or undesired sound or other acoustic disturbance. By extension, any unwanted disturbance within a useful frequency band, such as undesired electric waves in a transmission channel or device. Erratic or statistically random oscillation.

Frequency. The number of times per second that the sine-wave of sound repeats itself, or that the sine-wave of a vibrating objects repeats itself. Now expressed in Hertz (Hz), formerly in cycles per second (cps).

Decibel. Because of the large range in the intensity of audible sound, a linear scale of measurements is unmanageable. The logarithmic scale more closely resembles the response of the ear to sound, The unit used to measure sound is called a **decibel**, and is symbolically represented as **dB.** A decibel is not an absolute unit of measurement; for sound, it is defined as 20 times the common (base 10) logarithm of the ratio of the pressure produced by the sound of interest and a reference pressure which has been standardized at 20 micropascals, the pressure of a sound which is at the threshold of normal human hearing.

Loudness. Loudness is a subjective perception of the magnitude of sound. The loudness of sound depends on its intensity, the frequency of the sound, and the characteristics of the human ear. The intensity of sound is a purely physical property; whereas the loudness depends also upon the characteristics of the receptor ear. In other words, the intensity of a given sound striking the ear of a normal hearing person and of a person with a hearing loss might be the same, but the perceived loudness would be different.

Additionally, although a 3 dB increment in noise level represents a doubling of sound energy, the higher level does not sound twice as loud as the lower. In reality, a 3 dB difference in noise levels is only moderately detectable by the human ear. A difference on the order of 10 dB represents a subjective doubling of loudness. Thus, 3 dB corresponds to a factor of two in sound energy, while 10 dB corresponds approximately to a factor of two in subjective loudness.

A-Weighted Sound Level. A-weighting emphasizes sound components in the frequency range where most speech information resides, and thus yields higher readings (A-Weighted levels) for sound in the 2000 to 6000 Hz range, but considerable lower readings for low-frequency noise, than does the overall sound pressure level. The A-weighted sound level is used extensively in the U.S. for measuring community and transportation noises.

Air Installation Compatible Use Zone (AICUZ). The AICUZ program was initiated by the Department of Defense (DoD) to promote compatible land use development in the proximity of DoD air installations. The program involves working with local government agencies to implement the land use recommendations contained in AICUZ reports prepared for each installation having an active flying mission. The AICUZ program provides information to the communities concerning both the noise levels and accident potential associated with aircraft operations at the installation.

Ambient Sound. The issue of ambient sound is theoretically integral to determining of the usefulness of DNL, contours below DNL 65 dB threshold. Additional comparisons can be hypothesized for urban, rural, and various densities of suburban neighborhoods. The technical literature review on the issue of background noise or ambient sound impacts reveals a need for further research to determine the relationships between ambient sound and proposed metrics and methodologies existing below DNL, 65 dB.

Annoyance. The typical response of humans to aircraft noise is annoyance. The response is remarkably complex and, considered on an individual bases, widely varies for any given noise level. When average annoyance reactions within a community are considered, it is possible to discern aggregate annoyance response/noise level relationships. Frankel defines annoyance as, "a psychological response to a given noise exposure." It may result from speech interference, but can arise in a variety of other circumstances. The perceived unpleasantness of the noise is a factor, as is any anxiety or apprehension the noise may cause. Noise does not have to be loud to annoy; a loud noise may be pleasant to one individual and yet annoying to another.

Since one person's noise may be another persons music, a measure or index to account for subjective differences is not possible. Instead, the intensity of the noise sufficient to annoy most people is the method used to develop noise measurements. The establishment of noise standards may be based on the health and annoyance levels of the general public. The subjective nature of annoyance results in a small percentage of the population reporting a high degree of annoyance in relatively quiet settings; and other portions of the population unannoyed in environments capable of potential hearing loss (Federal Interagency Committee on Urban Noise 1980). Thus, guidelines directed toward annoyance must consider that some annoyance will occur at relatively quiet noise levels. These guidelines are contained as Table D-1 in the Guidelines for Considering Noise in Land Use Planning and Control. Federal Interagency Committee on Urban noise, 1980.

Community Noise Level (CNEL). The 24-hour A-weighted average sound level from midnight to midnight obtained after the addition of 5 dB to sound levels occurring between 1900 and 2200 hours and 10 dB to sound levels occurring between 2200 and 0700 hours, Units used are decibels.

Complaints. The analysis of complaints generally supports noise abatement (reduction) policies based on an assessment of the level of annoyance rather than the number of complaints. Annoyance can exist without complaints and, conversely, complaints may exist without adverse noise levels. The current body of evidence indicates that complaints are an inadequate indicator of the full extent of noise effects on a population.

Day-Night Average Sound Level (DNL or L_{dn}). Day-Night Average Sound Level (DNL) is a single number measure of community noise exposure. It is an enhancement of the 24-hour Equivalent Sound Level L_{dn} with a 10 dB penalty applied to nighttime (10 P.M. to 7 A.M.) sound levels to account for increased annoyance due to noise exposure during these hours.

Effective Perceived Noise Level (EPNL), expressed in dB or EPNdB. Effective Perceived Noise Level is a single number measure of complex aircraft flyover noise that approximates human annoyance responses. EPNL is used by the FAA as the noise certification metric for large transport and turbojet aircraft and helicopters.

Equivalent Sound Level (L_{eq}). Continuous average (on an energy basis) A-weighted sound level over a period of time.

Fast and Slow Sound Level. In decibels, the exponential-time-average sound level obtained with a squared-pressure time constant of 125 milliseconds for FAST and on second for SLOW.

Habituation. The ability of humans to acclimate to incremental increases in sound levels, intermittent increases in sound levels such as aircraft flyovers, and high ambient sound levels is an are recommended for further research. The issue of habituation has informally been the subject of discussions concerning the long-term consequences of proposed actions below DNL 65 dB; however, little scientific data was found in the technical literature review.

Highly Annoyed. Before and during the 1950s, the effects of noise were determined largely from anecdotal evidence, case studies, laboratory studies, and a very few social surveys. Even in those days, "annoyance" was given prominence. How annoyed people were as a consequence of the noise exposure was thought to be very important, and indeed that is the belief to the present day. Also, in recent years, there has been more emphasis on obtaining data on community response from social surveys of the communities involved. There has been a great effort directed toward finding a relationship between the noise exposure metric and some measure of activity interference (assumed by most researchers to be primarily communication interference) or annoyance as measured by a social survey. A wide variety of responses have been used in social surveys in an attempt to determine intrusiveness disturbance of speech communications or sleep, interference with TV or radio listening and interference with outdoor living. The overall response to all of these factors was measured by questions on the annoyance reaction. The concept of "percent highly annoyed" in the sampled population seemed to provide the most consistent response of a community to a particular noise environment. In an attempt to meet the demand for a usable and uniform relationship, Schultz reviewed the results of a number of social surveys where data were available to make a consistent judgment concerning what percent of the population was "highly annoyed" (%HA). The surveys were of community reactions to several types of transportation noise such as road traffic, railroad and aircraft noises. The results agreed fairly well with one another and he developed an equation for describing the relationship between the level of

exposure in DNL and %HA. This relationship was adopted by the CHABA Working Group 69 and was proposed by EPA in the "Levels Document" as the appropriate method for evaluation of the effects of noise on communities. The relationship has held up well for aircraft noise and produced reliable results in several subsequent studies. In 1989, Fidell et al. added 239 data points to the original 161 data points analyzed by Schultz for a total of 400 points. The U.S. Air Force Armstrong Laboratory uses a Logistics type regression curve fit for describing the relationship between DNL and %HA because it gives essentially the same predictive values as the function recommended in by Fidell et al. and has further advantage that no predictions of less that 0% or more than 100% can be obtained. Logistic fits to the 161 data points and to the 400 data points give such similar predictive values (within about 1%) that no advantage would be obtained by replacing the original Logistic equation for describing the relationship.

One question that still persists is whether the DNL-%HA relationship is the same for all types of transportation noise. Of the 400 data points, 173 were for aircraft noise, 170 for traffic noise, and 57 for railway noise. In the Armstrong Laboratory analysis, plots are given for logistic fits to each of these three sets of data points. Although values for traffic and railway noise are not as high as the values predicted for aircraft noise, at the higher DNL values, there are no statistically significant differences between predicted value at any DNL level.

Maximum Sound Level (L_{max}). The greatest sound level in decibels for a specific exponential-time averaging constant during a given time period. Abbreviation for maximum fast A-weighted sound level: MXFAL; quantity symbol: L_{max}.

Noise-Induced Permanent Threshold Shift (NIPTS). NIPTS is a permanent shift in human hearing threshold (a lowering of the sensitivity) due to noise exposure to noise. It is a sensory-neural type of hearing loss and is not reversible.

Noise Sensitive Area. An area in which aircraft noise may interfere with the normal activities associated with the use of land. Noise sensitive areas include residential neighborhoods, educational, health and religious structures and sites and outdoor recreational, cultural, and historical sites. Whether sound interferes with a particular use depends on the timing, level, duration, and frequency of the occupance of the sound exposure received and the type of activities involved.

Sleep disturbance (wake-ups). The threshold level of noise that will cause arousal from sleep. This threshold depends on the sleep stage and the age of the subject, among other variables. Noise levels that can cause sleep disturbance occur in the A -weighted range of 35 to 70 dB.

Sound Exposure Level (SEL). The level, in decibels, of the time integral of squared weighted sound pressure over a given time period or event, with reference to the square of the standard reference sound pressure of 20 micropascals and a reference duration of 1 second. The frequency weighting shall be specified, otherwise A-weighting is understood.

Speech Interference. The chief effect of intruding noise on speech is to mask the speech sounds and thus reduce intelligibility. The important contributors to intelligence in speech sounds cover a frequency range from about 2000 to 6000 Hz; and at each frequency, a dynamic level range of about 30 dB. This is a major factor associated with annoyance from aircraft noise. A number of metrics have evolved for assessing the influence of noise on speech. These include: (1) Preferred Speech Interference Level (PSIL), DEFINED as the arithmetic average of the sound pressure levels in the 500 Hz, 1000 Hz and 2000 Hz octave bands; (4) The Sentence intelligibility as a function of steady ambient noise level; and (5) the Articulation index (AI), a value between zero and 1.0 that describes the masking of speech by background noise. This value is found by evaluating the signal-to-noise ratio in specific frequency bands. Additionally, the L_{eq} metric that identifies the cumulative noise exposure for a specific period of time may also be used.

Time Above (TA), Expressed in Minutes. The duration, in minutes, for which aircraft-related noise exceeded specified A-weighted sound levels during a given period. The day TA metric applies to the period 7 a.m. to 7 p.m. , while the evening TA metric applies to the period from 7 p.m. to 10 p.m. and the night TA metric to the period 10 p.m. to 7 a.m.

24-Hour Time Above (TA), Expressed in Minutes. The duration, in minutes, for which aircraft-related noise exceeded specified A-weighted sound levels during a 24-hour period.